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Do Migrants Degrade Coastal Environments? Migration, Natural Resource Extraction and Poverty in North Sulawesi, Indonesia

Susan Cassels,[1] Sara R. Curran,[2] and Randall Kramer[3]

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 investigates these variables 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.

KEY WORDS: migrants; migration; North Sulawesi; fishing; modes of incorporation; coral reefs; local economies.

INTRODUCTION

Within the past two decades, the field of population and the environment has grown rapidly. Theories have expanded from simplistic linear

[1]Office of Population Research, Princeton University, Princeton, NJ 08544, USA; e-mail: scassels@princeton.edu.
[2]Department of Sociology and Office of Population Research, Princeton University, Princeton, NJ 08544, USA; e-mail: curran@princeton.edu.
[3]Nicholas School of the Environment and Earth Sciences, Duke University, Durham, NC 27708, USA; e-mail: kramer@duke.edu.

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 multiphasic 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 *et al.*, 2002; Curran and Agardy, 2002; Jodha, 1998; Katz, 2000; Naylor *et al.*, 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 focussed on three issues: the extent an ecological resource base attracts migrants (Bilsborrow and Ogendo, 1992; Bremner and Perez, 2002; Curran, 2002; Dwyer and Minnegal, 1999; Hunter, 1998; Ruilai, 1992); the extent migrants differ from non-migrants in their ecologically destructive behavior (Bilsborrow and Ogendo, 1992; Bilsborrow, 1992; Pichon, 1997; Sierra, 1999); and the extent the capacity of social institutions is strained by migrant incorporation and serves as a more proximate explanation for resource degradation (Bernacsek, 1986; Bertram, 1986; Bilsborrow and DeLargy, 1991; Bilsborrow and Carr, 2000; Connell, 1994; Connell and Conway, 2000; DeWalt and Rees, 1994; Dwyer and Minnegal, 1999; Ewell and Poleman, 1980; Gould, 1994; Jodha, 1985; Katz, 2000; McIntosh, 1993; Ostrom, 1990). As mentioned earlier, most of these studies have examined the impact of migration on the terrestrial environment. Fewer studies have examined the impact of migration on coastal or marine ecosystems. One reason may be that connections between the human "footprint" and terrestrial environments are more noticeable than the link between humans and

marine environments, since changes in the more inaccessible and fluid marine environment are often harder to discern.

Only recently have there been studies of migration and the marine environment (Bremner and Perez, 2002; Curran, 2002; Curran *et al.*, 2002; Curran and Agardy, 2002; Kramer *et al.*, 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, such as 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, 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—defined as a person born in another district—who comprise 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 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 Fig. 1). Every year thousands of international tourists visit the world-renowned Bunaken

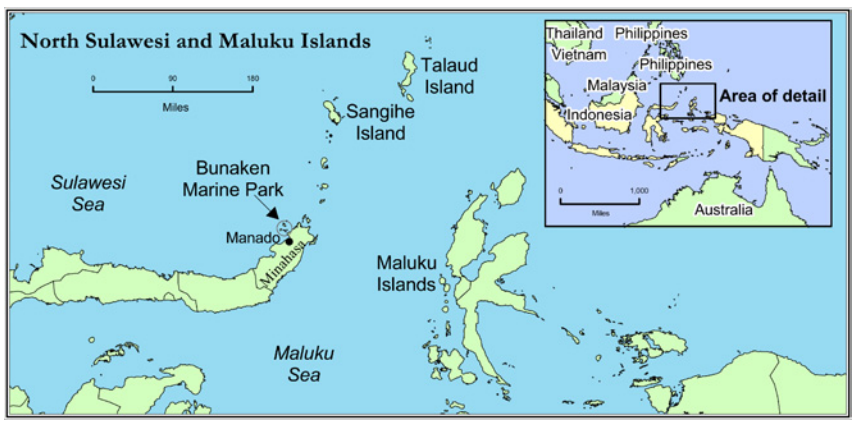

Fig. 1. A map of North Sulawesi.

Marine Park, located on the western side of the peninsula, to scuba dive among 2,500 species of fish and 70 genera of coral.

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 answers attempt to provide a first glimpse at the relationship between migration and marine resource quality and extraction. In this paper we show associations, such as whether migrants are associated with higher levels of poverty and shorter time horizons; without longitudinal data we cannot tell which came first: the migrants or the poor resource quality.

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.

THEORETICAL REVIEW

There is a popular consensus that migrants' resource-use and extraction strategies result in negative environmental impacts such as 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 that includes such mechanisms as differential access and use of technologies, differential valuation of and knowledge about ecosystem components, differential economic resources, differential time horizons, and 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 regimes (Katz, 2000; Ostrom *et al.*, 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 which limits free-rider problems associated with public goods (Palsson, 1998). An important difference between migrants and non-migrants regarding resource extraction is the value and benefits that each group places on the resource, which are often correlated with the amount of knowledge the group has about the resource and ecosystem (Browder, 1995) (Begossi, 1998; Begossi *et al.*, 2002).

Related to the differences between migrants and indigenous people is misapplication of resource extraction technologies (Perz, 2003). In the Amazon, recent settlers bring technology they are familiar with but which is poorly adapted to the new landscape ecology. In addition, recent migrants have an expansionist attitude toward new land which fails to consider long-term effects of resource-extraction and use on the ecosystem as a whole (Pichon, 1997; World Bank, 1992). This expansionist attitude has been recorded not only among contemporary migrants but also among historic colonizers, for example on several Pacific islands, whose impact caused species extinction, soil degradation, and erosion (Kirch, 2002). According to a study of a coastal population in northeastern Brazil, technological changes imposed by outsiders without knowledge of 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 tend to 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). 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 a study of a multiethnic region in Ecuador, Sierra (1999) did not find evidence of recent deforestation associated with new migrants. Other studies highlight systems with strong land tenure or social capital where migrants do not disrupt the environment (Hanna, 1998; Palsson, 1998) or are able to develop knowledge systems that are compatible with their 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 the impacts of migration and migrants' resource-use and extraction on the environment is mixed, partly due to the fact that migration is an extremely complicated, non-linear process (Curran, 2002).

Further, marine and coastal ecosystems are generally governed by common property resource management systems which may be particularly vulnerable to the disruptive effect of in-migration. 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. 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. Recent ideas about trust, embeddedness, and social cohesion as fundamental for understanding successful common property resource management systems (Ostrom *et al.*, 1999) are also key concepts for understanding immigrant assimilation in destinations (Portes, 1998).

To date, no empirical studies in the migration and environment literature have applied recent theoretical developments in the migration literature, specifically how modes of migrant incorporation are critical for understanding immigrant assimilation and behavior. 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 policies (such as transmigration policies) can facilitate access to resources that ease settlement costs and lengthen time horizons, limiting stress on local environmental resources. Alternatively, they may be indifferent or hostile, which may exacerbate the detrimental effect migrants have on an environmental resource base. The public's perceptions of migrants may be prejudiced, limiting their access to jobs or resources. The preexistence of large numbers of coethnics 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 form an enclave so internally diversified within the wider community that migrants do not have to interact with indigenous locals (Bailey and Waldinger, 1991; Light, 1984; Zhou, 1992). This concentration of migrants may focus and narrow their impact on an environmental resource base. For example 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 original communities (evidence from first author's field work in the summer of 2002). We include measures of migrant participation in this industry to demonstrate how this particular mode of incorporation conditions migrant impacts on coastal ecosystem quality.

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), which promote common property resource management systems. Aswani's (1999, 2002) case study in the Solomon

Islands challenges the notion that sea tenure regimes are 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.

Just as there has been relatively limited elaboration of how migration impacts the environment, so have there been relatively few studies of migrant impacts on coastal ecosystems. Our observation and estimation of how migrant incorporation through marriage or clustering in a fishing industry enclave can condition the impact of migration upon coastal ecosystem quality extend migration theory to models of population and environment.

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). 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 *et al.*, 1998). 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 both fragile and valuable. For example, coral reefs are among the most valuable and diverse ecosystems on earth due to the environmental and economic services they provide including invaluable biodiversity, seafood, new medicines, recreational value, and coastal protection (Cesar, 2000). They are critical habitat and nursery grounds for 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. While, the health of coral reefs depends greatly on human activities, the health and wellbeing of humans also depends greatly on coral reefs. Global warming has been identified as the major threat to coral reefs (Pockley, 2000). However, numerous other anthropogenic threats cause serious damage, including over-fishing, fishing with explosives and poison, 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, such as fishermen standing on reef shelves to throw their nets or scuba divers touching and breaking parts of the coral, can kill parts of the reef. Non-structural damage can also be catastrophic for coral reefs. 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. Encompassing nets capture and kill many non-target species (by-catch) thus impacting harvest pressure on more than the species sought. A change in the species structure due to intensive fishing can cause a reef ecosystem to completely shift to a state of overgrown fleshy microalgae (Scheffer *et al.*, 2001). Such anthropogenic disturbances to coral reefs, when rapidly compounded, have serious implications for long-term alteration, damage, and loss of productivity of the ecosystem (Paine *et al.*, 1998).

Studies of migration impacts on non-reef coastal resources find a complex set of factors at work. For example, 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 (Bremner and Perez, 2002). Now, the sea cucumber fishery is over-exploited and there are conflicts of interest about its future conservation. Other studies identify complex intervening variables between migration and the coastal environment, including biophysical characteristics of the marine system, dynamic fishery markets, seasonal migrant flows (Marquette *et al.*, 2002), migrant remittances (Jokisch, 2002; Naylor *et al.*, 2002), shifting markets, politics and technologies in shrimp farming (Lebel *et al.*, 2002), and the social and cultural history of the industry (Bene and Tewfik, 2001). 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 the number of people. Technology, knowledge systems, modes of incorporation, kinship, poverty, and resource valuation all play a role.

THE STUDY AREA

Indonesia's extensive coastline and long history of migration makes it an ideal place to study the relationship between migration and coastal ecosystems. 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 consequently, the livelihoods of a great proportion 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 form a natural bridge to the Philippines which has facilitated the movement of people and ideas for centuries. Sulawesi played a central role in the Spice Island trade with the Portuguese, and the Dutch capitalized on the district's strategic location during their colonization and had a strong presence in the area until Indonesia's independence in the 1950s. In general the people of Sulawesi are strongly oriented to the sea. For the past 50 years, work involving trade and fishing has been the primary reason for migration to the Minahasa district, and the anticipation of higher income is still the most common 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 (Fig. 1). 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 in the district. No point on the mainland is greater than 90 km from the sea and the interior of the island is extremely rugged and mountainous (Whitten *et al.*, 1987). 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.

Most migrants to Minahasa arrive by boat 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).

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 move into smaller villages and are incorporated into those communities via intermarriage. 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.

CONCEPTUAL FRAMEWORK AND HYPOTHESES

In this paper, we investigate whether migrant households are more highly associated with poor coral reef quality and whether the relationship is modified by resource extraction techniques, effort, poverty, and employment in the industrial fisheries sector.

Recent work on migration and the environment in addition to knowledge of our study area lead us to the following hypotheses. First, we expect to see that villages with poor environmental quality will have a higher proportion of migrants. Second, 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, and thus unsustainably extract natural resources. Alternatively, our knowledge of the Indonesian context and recent migration theory predicts that the way migrants are incorporated into their new communities will condition the observed negative associations between migrants and coral reefs. Specifically, we expect that intermarriage should diminish the negative association of migrants with poor environmental outcomes and destructive extractive techniques. And we expect that migrants' settlement enclaves in the urban, industrial, pelagic fishing sector also diminish their impact upon coral reefs.

DATA, MEASURES, AND METHODS

Data Collection

Our primary quantitative data come from a 1999 survey, conducted by researchers from Duke University and Bogor Agricultural University in Indonesia of 599 households in 17 coastal villages, concerning household demographics and economics, migration experience, fishing behaviors, and coastal resource use (Kramer *et al.*, 2002). The sample of households was obtained following stratified, multistage 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, subdistricts were stratified as east or west coast, and three subdistricts were selected randomly from each stratum. In the second stage of the sampling process, villages in the six subdistricts 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 (Kramer *et al.*, 2002).

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 semistructured interviews with migrants, family members of migrants, and nonmigrants 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, the source of 75% of the migrants to Minahasa (Fig. 1). The semistructured 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 renowned university-based 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. Coral reef coverage ranges from 0.45 square kilometers to 20.12 square kilometers with a mean value of 2.8 square kilometers. Ideal environmental data would be more recent, spatially explicit and at a higher resolution, but these were the best available environmental data for the area at the time and unusual for any study of the impacts of human behavior on coastal ecosystems.

Data Measures and Variables

We created an index of environmental quality based on coral reef quality and quantity. First, the 17 villages were grouped into two categories of coral reef quality: *average*, representing live coral cover between 25% and 75%, and *poor*, representing live coral cover between 0 and 25%. Additionally, we categorized the villages into those with *large* coral cover greater than the mean and those with *small* coral cover less than the mean. Generating a two-by-two cross-classification table, we created an index from the four cells of the table: poor quality/small area ($N = 3$ villages), average quality/small area ($N = 8$ villages), poor quality/large area ($N = 3$ villages), and average quality/large area ($N = 3$ villages).

We measure migrant status at the household level and build into our measure one form of migrant incorporation, intermarriage. Respondents qualify as migrants if they were born in a different district. The three categories of migrant status 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. 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 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 distinguish three variables: (1) the deployment of destructive fishing techniques, (2) the weekly fishing effort (in hours) performed by a household, and (3) boat ownership. Destructive fishing technique is measured with a question about whether fishers use gear considered destructive to coral reefs. The survey included questions to measure 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 indicate 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 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 variable of weekly fishing effort calculated by the number of hours spent fishing per week 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; there is no clear way to weight the variable effort for gear-type, although an hour fishing while using nets may be more detrimental than an hour with a hand-held spear. Nonetheless we found interesting variation among the households. A household with two migrants spends an average of 102 h per week on fishing compared to 78 h for a family with one migrant, and merely 68 h 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. It may also reflect the ability to be out to sea longer and

possibly cause more damage, but we measure that directly with the fishing effort variable. 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 (data not shown).

Using information on the size of boat used by the fisher, we derive our second measure of migrant incorporation. Whether or not a person owns a boat, they may still fish on or off 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 and not near coral reefs.

Poverty is frequently difficult to measure in many less developed country settings and 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 did not construct a poverty line for our 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 per week on numerous items, including food, clothing, education, house maintenance, etc. From these data we calculate an aggregate measure of household expenditures in Indonesian rupiah, which is the natural log of the sum of all categories of spending.

Analytic Approach and Methods

The analysis is organized into three general sections: a village level analysis, household level analysis, and a fully interactive or conditional, multivariate analysis. 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. 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.

We analyze the social and ecological context at the village level using Tukey's simultaneous *t*-tests 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.

For the household level analyses we 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 bivariate evaluation is based on a chi-square distribution. Then we estimate multivariate models predicting the odds of a particular resource extraction behavior and a household's poverty level. We estimate three models: the first evaluates the relationship between migrant household status and the dependent variables, the second includes demographic factors and the environmental quality of the coral reef, and the third includes measures of fishing sector, or boat size. For the models estimating two of the resource extractive behaviors (destructive gear use and boat ownership), we employ a random effects logistic estimation technique. For the models estimating fishing effort we employ 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 for predicting household expenditures.

Because households are clustered within villages we employ random effects regression models. Note that the example below is a linear regression model, written to illustrate our technique, but we also use logistic models in the analysis. 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}, which does not vary across households within a village, a random variable z_j, and a random error term:

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

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.

In the third set of analyses, our conditional multivariate models, we separately estimate extractive behaviors and poverty within each type of fishing sector. In effect we are testing an interaction among 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.

VILLAGE LEVEL RESULTS: 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 I and II. In Table I 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 variation among villages.

On average, villages with a small amount of poor quality coral have larger populations. Generally, they are three times larger than the other villages. 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. Migrant composition across village is startlingly different for the group of villages with a small quantity of poor quality coral reefs. On average, 18.6% of the households in these villages are composed of two migrants, while 35.5% are one-migrant households.

Table I. Village Level Demographic, Ecological, and Behavioral Characteristics

Variable	Small coral reef		Large coral reef	
	Poor quality	Average quality	Poor quality	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)	1.67	1.15	5.34	12.10
Migrant status				
Proportion of HH with two migrants	0.19	0.04	0.00	0.00
Proportion of HH with one migrant	0.36	0.27	0.24	0.27
(Ref: HH with no migrants)	0.46	0.69	0.76	0.73
Household demographics				
Average age of respondent	37.32	39.66	41.86	38.67
Average family size	4.52	4.50	4.94	4.12
Fishing behavior				
Proportion of HH using destructive gear	0.45	0.19	0.29	0.19
Proportion of HH that own a boat	0.35	0.70	0.93	0.92
Average hours of fishing effort per HH	91.35	62.66	51.10	65.23
Crew size (Proportion of HH that fish on a boat with . . .)				
$\leq$2 members	0.28	0.75	0.50	0.93
3 to 10 members	0.12	0.19	0.45	0.07
(Ref: more than 10 members)	0.60	0.06	0.05	0.01
Poverty measure				
Natural log of HH spending (rupiah)	11.55	11.62	11.38	11.40

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

Table II. Pairwise Comparison of Means: Results of Tukey's Simultaneous *t*-Tests

Variable	Poor/large Poor/small	Average/small Poor/small	Average/large Poor/small	Average/small Poor/large	Average/large Average/small	Average/large 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)	(+)*	(+)ms	(+)ms			
Household demographics						
Average age of respondent						
Average family size						(−)*
Fishing behavior						
Proportion of HH using destructive gear			(−)ms			
Proportion of HH that own a boat	(+)*	(+)*	(+)*			
Average hours of fishing effort per HH	(−)*	(−)*	(−)ms			
Crew Size (Proportion of HH that fish on a boats with . . .)						
<=2 members	(+)ms	(+)*	(+)*	(+)*		(+)*
3 to 10 members	(−)*			(−)*		(−)*
(Ref: more than 10 members)	(−)*	(−)*	(−)*			
Poverty measure						
Natural log of HH spending (ln rupiah)					(−)ms	

Note. * = significant at 5% level; ms-significant at 10% level.

with average coral reef quality, near 19% on average for villages with small and large coral reefs.

Villages with poor quality and a small area of coral 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.

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 h fishing per week. Households in villages with average quality coral, regardless of coral reef size, spend around 63–65 h of fishing, while households in villages with poor quality and large coral reefs spend the least time fishing, at 51 h for the average household.

Fishing on large boats with 10 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 on small vessels, while the rest fish on medium size boats with three to ten crew. 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 small coral reefs of poorer quality, while the rest of the villages mostly fish on small and medium crew boats. Nonetheless, we cannot assume that fishing on large boats causes environmental destruction. In this study, boats are found in villages close to urban areas, and the coastal environment in these areas is prone to many other population pressures, such as sewage, leaking fuel, and anchor damage.

Average household expenditures are 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 II). Most of the significant differences emerge in comparisons involving villages with poor quality and small coral reefs, the first three columns of the table. Most strikingly but perhaps not surprisingly, villages with poor coral reef quality

and small quantity have significantly larger populations. Indeed, two out of three of the villages with poor coral reef quality and small quality are on the outskirts of an urban area, a fact that drives this significant finding. A significantly higher proportion of two-migrant households are in villages with poor quality and small coral reefs. 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 an average age in villages with a large area of coral is significantly older at 41.9 years. Yet when using the stringent Tukey's *t*-test, there are no significant differences in age composition across villages. As for family size, only one significant difference emerges 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. There is only one statistically significant difference, though. Fishers in villages with poor quality and small coral reefs are significantly more likely to use destructive fishing gear than fishers in villages with average quality and large coral reefs. A significantly lower proportion of households in villages with poor quality coral reefs own their own boats. Villages with large coral reefs have the highest percentage of households owning a boat. 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.

Members of fishers in villages with small reefs of poor quality are significantly less likely to work on small boats than fishers in other villages. Fishers from villages with average quality coral reefs are significantly more likely to work on small boats than fishers in villages with poor quality coral reefs. Fishers 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. 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 large boats and those who fish on a smaller scale. Pelagic fishermen on large boats exploit different resources than 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 and had 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 seasonally migrate to the most lucrative destination for work. 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 Minahasa 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 LEVEL RESULTS: MIGRANT STATUS, FISHING BEHAVIOR, AND POVERTY

A bivariate comparison of household migrant status and settlement near coral reefs, demonstrates that two-migrant households are significantly

Table III. 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	

Note. Chi-square test significant at 1% level.

more likely to settle near small coral reefs of poor quality than near reefs with other characteristics (Table III). One-migrant households are also significantly more likely to be located near small coral reefs of poor quality than to be located near 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.

Thus far, we might conclude that migrant status is associated with lower quality coral reefs. However, we must be cautious 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 previously deteriorated 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 IV 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.

Table IV. Four Random Effects Models on Destructive Gear Use, Fishing Effort, Boat Ownership and the Natural Log of Spending (Log-Odds Coefficients Reported for Logistic Equations (Standard Errors))

	Destructive gear (1 = yes)			Fishing effort (hours per week)			Own a boat (1 = yes)			ln(Spending)		
	Logit model			Linear model			Logit model			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)												

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		−1.083			−30.018			2.585			0.148	
members		(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

Note. N/A: Environmental variables dropped due to collinearity with boat type variables.
**significant at 1%, *significant at 5%, ms = marginally significant at 10%.

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) and find that the odds of a two-migrant household using destructive gear fall 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.

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 control 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, while 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 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. We do not find an association between household size and fishing effort as others have (Durrenberger, 1979; Sosis *et al.*, 1998). 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 account for 24.3% of the variance in boat ownership, and 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.

CONDITIONAL RELATIONSHIPS: MIGRANT EFFECTS WITHIN FISHING SECTORS

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 fishing on a small scale near coral reefs, and those fishing 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 V 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, 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 IV are due to migrants working on large fishing boats. Two-migrant households are significantly less likely to use destructive gear than are non-migrant households when they work on large fishing boats. Similarly they spend more hours fishing per week, and they spend less. The impact of migrants on 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 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 industrial fishing that relies on migrant labor to fulfill their contracts, and urban areas where the industry is located. Urban areas attract large numbers of people, and no matter what type of extractive technology they are using, the sheer number of people will impact fragile ecosystems like coral reefs.

DISCUSSION AND CONCLUSION

Variation in ecosystems and the social and economic environment greatly affects the relationship between a population and its environment (Jones, 1996). The connection between demography and the environment is not linear, and can be 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 sense is that ecological as well as social context matter more than migrant status, yet the two are interconnected.

Table V. Separate Regression Analyses Within Fishing Sectors

	Destructive gear (1 = yes)		Fishing effort		Own a boat (1 = yes)		ln(Spending)	
	Logit model		Linear model		Logit model		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

Note. These models include the same controls as the models from Table IV.
**significant at 1%, * significant at 5%, ms = marginally significant at 10%.
[#]No two-migrant households own a large fishing boat.

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 located in villages with lower environmental quality. On a village scale, there are significant differences among villages in terms of the proportion of migrants, average household size, age, destructive gear use, boat ownership, and hours of effort spent fishing. 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 many migrant households 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 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 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 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 possibility is the key to clarifying the interactions 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, intermarriage, and urbanization, which are mediating variables between migrants and their impacts on the environment. *Independent of poverty*, 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, suggesting 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 intermarriage or gain kinship and social ties, our results suggest that there are no behavioral differences that imply migrants degrade coastal environments.

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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