How and Why Alternative Incomes Fail to Reduce Fishing and Improve Human Welfare

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ABSTRACT

Alternative income programs are a common strategy used to reduce resource extraction and improve human welfare but it is unclear whether these programs are successful because they are rarely implemented with evaluation in mind. Taking advantage of a natural experiment in Kiribati, Central Pacific, we tested the effect of an agricultural subsidy on fishing and human welfare. We developed a model of household fishing and agricultural production and consumption. Contrary to predictions of this model and the programs aims, some households actually increased fishing and decreased agricultural labor. To explain these data, we developed an alternative model in which households also derive utility from labor in fishing. This model predicts an increase in fishing in response to the subsidy when households have a revealed preference for fishing prior to the subsidy, which was supported empirically. Conservation-development strategies therefore need to consider heterogeneity in household behavior and non-market benefits from traditional livelihoods.

INTRODUCTION

Fishing is a primary cause of global coral reef decline (Jackson *et al.* 2001, Pandolfi *et al.* 2003). Marine reserves have been created to reduce fishing pressure; however, only 9% of reserves are successful (e.g. prevent poaching) (Mora *et al.* 2006). Improved implementation and evaluation of incentive-based conservation strategies such as enforcement, conservation payments, and alternative income

programs are needed to reduce fishing pressure on coral reefs. While there has been relative success using only enforcement for protected areas generally (Bruner *et al.* 2001), pure enforcement schemes often provoke conflict, which may undermine conservation efforts (Ferraro & Kramer 1997). Some marine reserves and other fisheries management tools are designed to compensate fishermen for their loss in fishing grounds or catch in one period by improving their total catch and profits in the long-run (Sanchirico *et al.* 2005). However, short-run and even long-run welfare losses often occur due to the environmental (e.g. very low or very high dispersal benefits relative to foregone harvest) or market setting (e.g. incomplete resource market or complete labor market) (Sanchirico & Wilen 2001, Muller & Albers 2004). Consequently, some alternate form of compensation is needed for conservation strategies to be successful (Wells *et al.* 1992, Tisdell 1995).

Integrated conservation-development programs (ICDP) have emerged in the last three decades in response to this need. ICDPs attempt to create or enhance alternative incomes as a way to reduce resource extraction and improve local welfare (Wells *et al.* 1992). Increasing agricultural productivity is expected to decrease reliance on natural resources and is a typical strategy used in ICDPs (OECD 1996, Wilkie & Godoy 2000, Bennett 2002). The majority of the work on agricultural development and natural resources has been in terrestrial environments, particularly tropical forests (e.g. Oates 1999). There are few examples examining the effect of alternative incomes on marine resources (Wilcox 1994, e.g. Pollnac *et al.* 2001, Sievanen *et al.* 2005, Thiele *et al.* 2005).

Reviews of ICDPs have found few successes (Wells *et al.* 1992, Smith *et al.* 1998, Wells *et al.* 1998, UNDP 2000, Hughes & Flintan 2001). The major challenge in understanding how and why ICDPs fail is that few ICDPs are designed with evaluation in mind. Data is rarely collected before and after implementation, and, more importantly, non-random implementation generates a strong selection bias. Rather than randomly selecting treatment and control villages or households so that one can estimate the effect of the treatment, controlling for other changes across time, villages or households are often chosen for political or economic reason or self-selected. In the case of self-selection, the treatment group is biased because it will contain households that are most likely to give up the resource extractive activity. Here, we were able to take advantage of a natural experiment in the Republic of Kiribati that had limited selection bias. In 2004, the government of the Republic of Kiribati subsidized the buying price of copra, a coconut product, with the aim of reducing fishing pressure on local reefs and improving welfare. Given that almost all households in Kiribati engage in fishing, own some land with coconut trees, and both fishing and copra production do not require significant capital investments, virtually all households were included in the treatment.

In this paper, we first develop a simple model of the household that represents the standard assumptions that motivate ICDPs. This model predicts that a copra price subsidy should increase labor in copra, decrease labor in fishing, and improve overall welfare. However, this model does not explain the observation of a significant number households *increasing* fishing labor and *decreasing* copra labor over the time period

covering the price subsidy increase. We thus develop an alternative model that simply assumes fishermen may enjoy fishing. This model predicts that if fishing labor is equated to leisure households will increase fishing labor in response to the price subsidy. We tested the predictions of this model on data collected from a survey of 329 households in 2007 that collected retrospective data on labor allocation, income, production, capital, household attributes, and opinions on changes in welfare and fisheries, as well as income satisfaction covering the period 2001 to 2006. Our results suggest that households respond heterogeneously to the copra subsidy and that enjoyment of fishing caused the copra subsidy to have an overall perverse effect on fishing labor. These results have important implications for ecosystem health, long-run welfare, and the design of ICDPs when significant non-monetary benefits may be derived from an occupation.

This paper is organized as follows: section two reviews the existing literature on ICDPs and non-monetary benefits of particular occupations; section three presents the models of the household and the comparative static results; section four presents the estimation strategy, section five describes the data, section six presents the empirical results; and section seven discusses the results, focusing on implications for the ecosystem, welfare, and ICDP design.

EXISTING LITERATURE

Integrated conservation and development programs (ICDP) aim to fulfill both conservation and economic development goals (Worah 2000). ICDPs most often involve a complimentary biodiversity conservation program, such as a protected area, and a rural development program (Hughes & Flintan 2001). More broadly, ICDPs are rural sustainable development programs. As of 2001, there were an estimated three hundred or more ICDPs worldwide, supported by hundreds of millions of dollars from governments and international donor (Hughes & Flintan 2001). Designing and implementing successful ICDPs has been far more difficult than marketing the idea and raising the funds (Wells et al. 1998). Yet, it is still unclear if ICDPs have failed and why because few ICDPs include objective evaluation components that gather empirical data on both biological and economic outcomes (Kremen *et al.* 1994, Larson *et al.* 1997, Smith *et al.* 1998).

The rural development components of ICDPs take various forms including social or infrastructure development, adding value to natural resources through marketing and ecotourism, resource access and benefit sharing, and alternative livelihoods such as agriculture, agroforestry, and crafts. In this paper, we focus on an alternative livelihood program. Alternative livelihood programs have been criticized for not providing a clear link between conservation and development and for decreasing conservation incentives by weakening the dependence on the natural resource (Hughes & Flintan 2001). Moreover, many failures have been attributed to a lack of understanding of the cultural context in which the programs are introduced.

On the positive side, alternative income programs associated with marine protected areas have been suggested to increase compliance with new regulations (Thiele *et al.* 2005, Pollnac *et al.* 2001) and to be a good predictor of various measures of MPA success, including coral mortality, perceived resource change, infrastructure, and community empowerment (Pollnac *et al.* 2001). However, alternative incomes have been also associated with lower perceived quality of life and involvement in conservation activities (Thiele *et al.* 2005). A major problem with these studies, however, is that it is impossible to separate the effect of alternative incomes and investment in marine protected area programs broadly. Moreover, the authors of these studies did not explicitly measure changes in fishing labor allocation or fish stocks.

Sievanen *et al.* (2005) investigated whether fishermen who were encouraged to engage in seaweed farming reduced their fishing pressure. But this study is limited by the fact that it only observed fishermen who were self-selected, rather than randomly selected into the program, and did not measure any biological outcomes. The study showed that seaweed farming significantly increased income and was also associated with increased ownership of electronics and sometimes fishing capital. However, it was not associated with a decrease in the number of fishermen or fishing effort. Sievanen *et al.* (2005) argue that a lack of reduction in fishing pressure may be due to the fact that seaweed farming only requires labor periodically and that labor may be provided by women and children. Most fishermen that engaged in seaweed farming never gave up fishing entirely.

In order to understand why fishermen would not switch to an alternative livelihood that provides a much higher income, such as seaweed farming, we need to consider the non-monetary benefits associated with fishing. Wage rates in alternative livelihoods programs may understate the opportunity cost of fishing if non-monetary benefits are significant (Berman 1997). Anthropologists (Pollnac & Poggie 1988, Gatewood & McCay 1990) suggest that the enjoyment of fishing explains why fishermen often choose fishing over other jobs with higher wages. Attitudinal surveys of fishermen in the Philippines report that fishermen will not give up fishing for other occupations (although they would consider them for supplemental income) because they enjoy the income and lifestyle associated with fishing (Pollnac *et al.* 2001, CRMP 2000). This attitude is not particular to developing countries. North American fishermen have high levels of job satisfaction that are attributed to factors that represent "self-actualization," suggesting that fishing relates to individuals' need to fulfill themselves, rather than just their need to sustain themselves (Smith 1976, Apostle *et al.* 1985, Pollnac & Poggie 1988). These attitudes may be associated with other types of traditional livelihoods and explain, in part, why development programs are limited in their effect on rural communities.

HOUSEHOLD MODEL

We develop here a model of the household under standard assumptions and show that increasing the wage in the alternative income activity, copra production, should reduce fishing and improve welfare. We then show that observed household

behavior in Kiribati is not consistent with the predictions of this model, motivating the development of an alternative model that allows analysis of possible non-monetary benefits from fishing.

Standard Model

Consider a household that makes its living through the production of copra, the dried meat of coconuts, or other economic activities, primarily fishing. The local fishery is open access and fishing is mostly done on nearby coral reefs with simple technology, such as handlines, gillnets and canoes (and sometimes with small motors). Fish are either consumed by the household or sold in local markets. Coconuts are harvested from trees on household land. Little to no improvement is done to the land[1]. Coconuts simply fall to the ground, are collected by household members, and the meat is removed and dried. Copra is sold to local agents from the government owned copra exporting companies. Cash from copra is primarily used to purchase rice, which is imported. We will ignore capital because land and credit markets are non-existent or incomplete and instead focus on options of the household close to the extensive margin. In addition, there are no formal labor markets, so household production is almost totally dependent on household labor only.

[1] Although copra plantations existed in Kiribati when it was a British Colony, copra production since independence is done on household land and rarely involves fertilizer, clearing of undergrowth, or intentional planting of coconut trees. Coconuts are left to grow into trees or harvested opportunistically.

In this economy, the standard household problem is to maximize utility from consuming rice (r), fish (f) and leisure (l) subject to the household's income and labor endowment ($\bar{L}$).

(1) $$\max_{r,f,l,L^c} u(r, f, l)$$

(2) $$\text{s.t. } r + p^f f = p^c G(L^c) + H(L^o)$$

(3) $$\bar{L} = l + L^c + L^o, l > 0, L^c > 0, L^o > 0, r > 0, f > 0$$

Total imputed household income is derived from the value of copra production ($p^c G(L^c)$) and productivity of other labor ($H(L^o)$), where p^c is the government purchasing price of copra, L^c is household labor in copra, and L^o is household labor in other activities. In this model, all income is spent on rice and fish and p^f is the local price for fish. We normalize on the price of rice, the wage in other activities, and focus on an interior solution where households consume some rice, fish, and leisure and participate in both fishing and copra.

The first order conditions for an interior maximum are:

(4) $$\frac{\partial u / \partial f}{\partial u / \partial r} = p^f$$

(5) $$\frac{\partial u / \partial l}{\partial u / \partial r} = \frac{\mu}{\lambda}$$

(6) $$\frac{\partial H / \partial L^o}{\partial G / \partial L^c} = p^c$$

(7) $$r + p^f f = p^f F(L^f) + p^c G(L^c)$$

(8) $$\bar{L} = l + L^f + L^c$$

As expected, equation (4) requires consumption decisions to be made such that the marginal rate of substitution between rice and fish is equal to the price ratio. Similarly, equation (5) requires that the consumption of rice relative to leisure is equal to ratio of the shadow price of labor and income. Labor allocation decisions are to be made such that the marginal rate of technical substitution should equal the wage ratio (6). Also, the household spends all its income on consuming rice and fish (7) and the sum of leisure and labor in copra and other activities must equal the household labor endowment (8).

Comparative Statics

Predictions of how households will respond to a copra subsidy, which results in a higher copra buying price, p^c, follow directly from the first order conditions. First, we assume that the marginal productivity of other labor is constant and that the marginal productivity of labor in copra is decreasing. These may be reasonable assumptions because fishing in Kiribati occurs mostly close to shore, while extensive reef areas remain unfished or lightly fished due to distance and low technology. In contrast, land resources are very limited on Kiribati atolls and most household land can be reached on foot. Under these assumptions, if the price of copra increases, consumption of all goods will increase (assuming all goods are normal) and either the marginal productivity of copra labor must decrease or labor in copra must increase. Therefore, households would be expected to unambiguously increase copra labor at an interior solution.

Second, we assume that both marginal productivity of copra labor and all other labor is decreasing. If the price of copra increases, the consumption of all goods will increase if all goods are normal. The ratio of the marginal productivity of other labor to copra labor must increase to compensate for the increase in the price of copra. Three alternative changes in labor allocation may occur in order to make this adjustment: a) decreases in copra labor may be associated with large decreases in other labor and increases in leisure ($L^c < 0, L^o << 0, l >> 0$), b) increases in copra labor may be associated with decreases in other labor of similar magnitude and ambiguous changes for leisure ($L^c > 0, L^o < 0, l ?$), and c) large increases in copra labor may be associated with smaller increases other labor and decreases in leisure ($L^c >> 0, L^o > 0, l < 0$). The third scenario is eliminated if all goods, in particular leisure, are assumed to be normal.

A simple comparison of household copra labor, other labor, and leisure before (2001) and after (2006) the copra subsidy shows that the standard model predicts 23.25% of households' responses under the first set of assumptions and 28.03% of households' responses under the second set of assumptions (Table 3-1). A remaining 26.75% or 21.97% of households' responses are not predicted by the standard model (Table 3-1). Half of households' responses do not fit the assumption of an interior solution (some labor did not change over the period), which may be the result of using recall data (see section on data) (Table 3-1). Importantly, 21.97% of households increase other labor and 26.75% of households decreased their labor in copra, which was the opposite of the result intended by the copra subsidy (Table 3-1). These

observations show that the standard model is insufficient to describe the observed behavior.

Table 3-1. The percentage of households by changes in copra labor, other labor and leisure between 2001 and 2006.

Case	Changes in Labor	% Households
1	$L^c < 0, L^o < 0, l > 0$	19.11
2	$L^c < 0, L^o > 0, l < 0$	3.18
3	$L^c < 0, L^o > 0, l > 0$	4.46
4.	$L^c < 0, L^o > 0, l = 0$	0
5.	$L^c < 0, L^o = 0, l > 0$	3.50
Subtotal		30.25
6.	$L^c > 0, L^o < 0, l > 0$	5.10
7.	$L^c > 0, L^o > 0, l < 0$	14.33
8.	$L^c > 0, L^o < 0, l < 0$	3.82
9.	$L^c > 0, L^o < 0, l = 0$	0
10.	$L^c > 0, L^o = 0, l < 0$	5.10
Subtotal		28.35
11.	$L^c = 0, L^o > 0, l < 0$	14.33
12.	$L^c = 0, L^o < 0, l > 0$	11.15
13.	$L^c = 0, L^o = 0, l = 0$	15.92
Subtotal		41.40
TOTAL		100.00

Alternative Model

It seems possible that general equilibrium effects due to an increase in the price of copra could explain the increase in other labor (primarily fishing) because an increase in consumption of fish could lead to an increase in the price of fish, drawing

labor back into fishing. However, in order for this to occur, the price of fish would have to increase faster than the price of copra[2], which we do not observe (Figure 3-1).

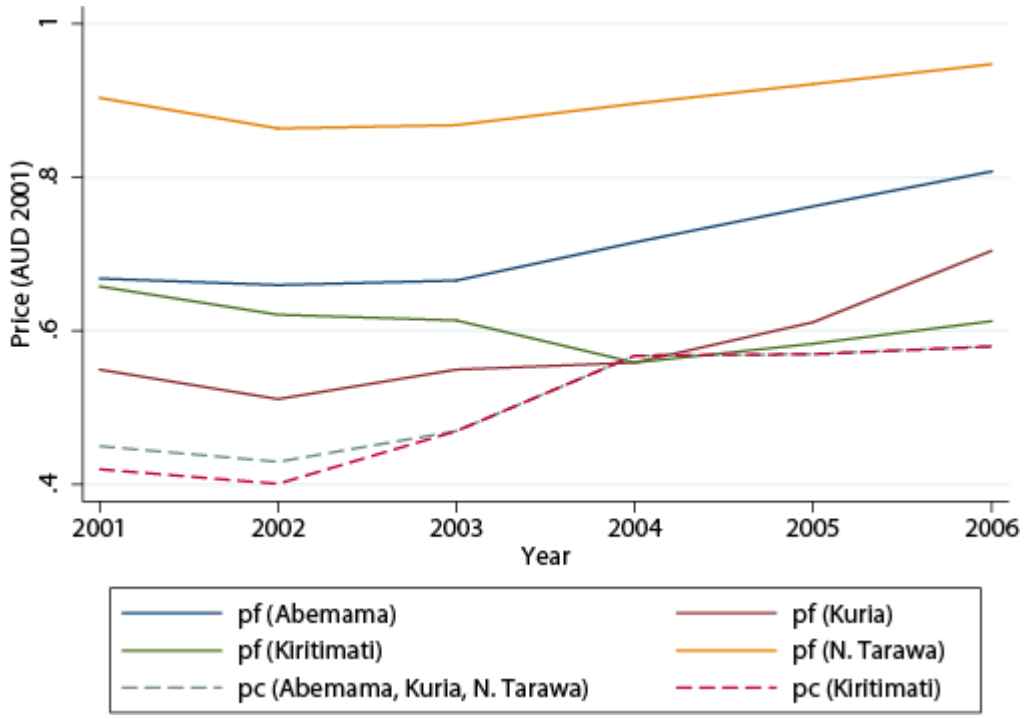

Figure 3-1. Copra and fish prices by island and year.

An alternative, more parsimonious, mechanism by which labor in fishing might increase in response to the copra price increase would be if people like to fish.

[2] This follows directly from the first order conditions (6). Given that fishing is the primary activity other than copra, the price of fish is the equivalent to the wage for other labor and the first order condition could be re-written as $\frac{\partial F / \partial L^f}{\partial G / \partial L^c} = \frac{p^c}{p^f}$. If the price of fish increased faster than the price of copra, labor would be drawn back into fishing to compensate for the change in the wage ratio.

Fishing produces fish but it may also provide direct benefits through the act of fishing[3].

In an alternative model that includes fishing as a consumption good, the household problem is to maximize consumption from rice (r), fish (f), leisure (l), and fishing labor (L^f) subject to household income and the labor endowment ($\bar{L}$).

(9) $$\max_{r,f,l,L^c,L^f} u(r, f, l, L^f)$$

(10) $$\text{s.t. } r + p^f f = p^c G(L^c) + p^f F(L^f) + \tilde{H}(L^o)$$

(11) $$\bar{L} = L^c + L^f + L^o + l, L^c > 0, L^f > 0, L^o > 0, l > 0, r > 0, f > 0$$

Assuming all goods are normal, under this model specification, we would expect that an increase in the price of copra would increase the consumption of all goods, including fishing labor. If both fishing labor and leisure increase, the sum of copra labor and all other labor must decrease. The predictive power of this model, relative to the standard model, and the expected magnitude of the change in fishing labor will depend, in part, on households' enjoyment of fishing relative to other consumption goods.

EMPIRICAL ESTIMATION

To test the predictions of our models, we considered reduced form models of copra and fishing labor:

[3] This seems to be a reasonable assumption that may be general to fishing, given the anthropological evidence for significant non-monetary benefits from fishing (Pollnac & Poggie 1988, Gatewood & McCay 1990), and specifically to this study, given personal observations of enumerators employed for this study complaining about not being able to fish.

(12) $$\ln(L_{it}^{c}) = \alpha_i^0 + \alpha_i^1 p_t^c + \alpha_i^2 p_t^f + \varepsilon_{it}$$

(13) $$\ln(L_{it}^{f}) = \beta_i^0 + \beta_i^1 p_t^c + \beta_i^2 p_t^f + \varepsilon_{it}$$

where the price of copra, p_t^c, and the price of fishing, p_t^f, predict labor allocation. Ideally, we would estimate these equations for each household individually; however, given the limited data on each household we instead used household specific interaction terms to separate general responses from household specific responses. Labor allocation, for instance, responds to price changes generally and specifically based on household characteristics. Household demographics, D_{it}, are represented in the constant terms, $\alpha_i^0 = \left(\alpha^3 + \alpha^4 D_{it}\right)$ and $\beta_i^0 = \left(\beta^3 + \beta^4 D_{it}\right)$. Household preferences for goods that can be purchased with cash (i.e. rice) and fishing are unobservable and, hence, the fraction of labor in copra and fishing in the first time period were used to instrument for these preferences, respectively. Consequently, the response of labor in the two production activities to a change in copra price has a general component and household specific component, $\alpha_i^1 = \left(\alpha^5 + \alpha^6 \times \frac{L_{i0}^c}{L_{i0}^c + L_{i0}^f}\right)$ and $\beta_i^1 = \left(\beta^5 + \beta^6 \times \frac{L_{i0}^f}{L_{i0}^c + L_{i0}^f}\right)$. The response of labor to a change in fish price is represented similarly, $\alpha_i^2 = \left(\alpha^7 + \alpha^8 \times \frac{L_{i0}^c}{L_{i0}^c + L_{i0}^f}\right)$ and $\beta_i^2 = \left(\beta^7 + \beta^8 \times \frac{L_{i0}^f}{L_{i0}^c + L_{i0}^f}\right)$. These models were tested using data from a household survey conducted in the Republic of Kiribati.

DATA

Data on individual households over the period 2001-2006 was collected by implementing a national level household survey in May and June 2007. It was necessary to use retrospective data collection because the data of interest were either not collected or were only available in aggregate. The survey instrument was developed with input from officers from the Ministry of Finance and Ministry of Fisheries and pre-tested on 85 households on two islands in December 2006.

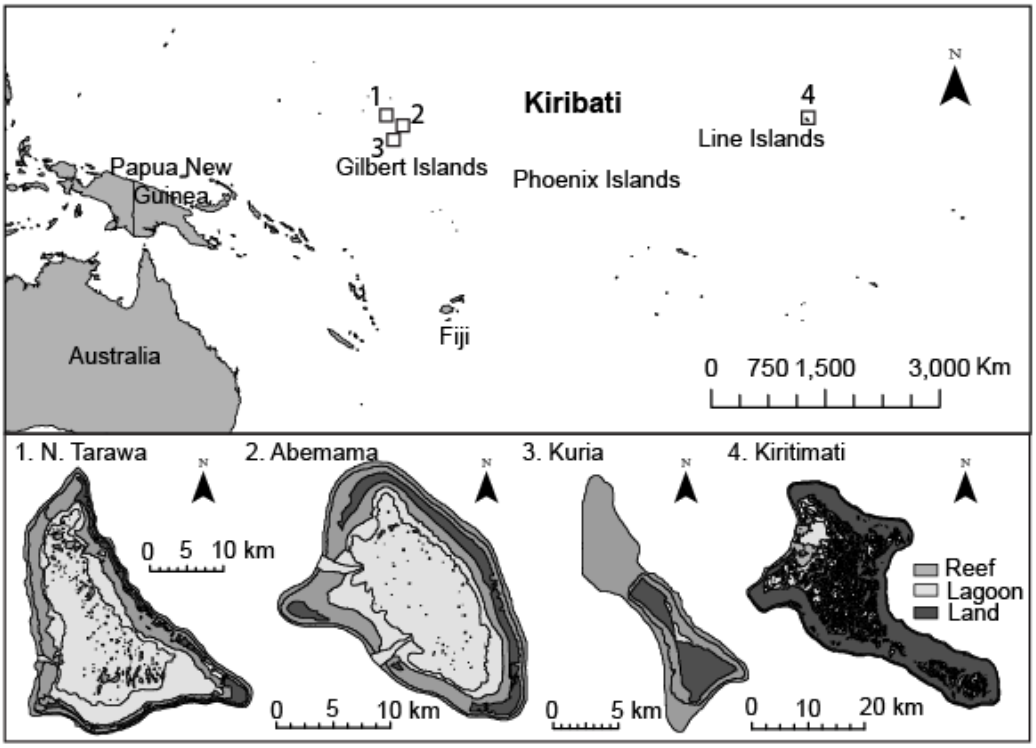

Figure 3-2. Map of study sites. The Republic of Kiribati is comprised of 33 islands in three island chains: Gilbert, Phoenix, and Line Islands. Four islands out the 20 populated islands were chosen by the probability that a household from each island would appear in a random sample of the population. The four study islands are 1) N. Tarawa, 2) Abemama, 3) Kuria, and 4) Kiritimati. Focused ecological surveys were conducted on Kiritimati.

Sampling Design

A cluster sampling design was used for the household survey. A total of 329 households were surveyed on four islands (Figure 3-2) and asked retrospective questions covering the period 2001-2006. This resulted in a 2% sample of the population and a total of 1,974 observations. Each island was considered as a different cluster. Islands were chosen based on the probability that a household would be drawn from a random sample of the population (households per island/total households). The target number of households surveyed at each island was proportional to the population of the island. Households from each village in a given island were surveyed in order to capture the variability within each island. Households are generally arranged linearly along the single or main road that runs the length of each island. This arrangement was used to randomly select households. A random number from 1-5 was chosen prior to entering a village and every n^{th} household was visited.

Survey Design

The survey was designed to obtain data on income, labor, and production from various economics activities, income from other sources, capital related to fishing and copra, ownership of household goods, and household characteristics over the period 2001 to 2006. The survey also included discrete choice and open ended questions

about welfare, income options and satisfaction, and the status of the fishery and conservation.

Survey Implementation

Surveys were conducted by the author and a trained field assistant with translation by local Fisheries Assistants. Upon arriving at a household, a household head (male or female with sufficient knowledge of household activities) was identified. The purpose of the project and the nature and duration of the survey was described generally prior to asking for oral consent. Quantitative answers were obtained for capital ownership, household goods, and household characteristics. However, for income, labor and production, quantitative data was obtained for as many years as the subject could recall and five-level Likert scale was used for the other years. The survey was followed by de-briefing questions.

EMPIRICAL RESULTS

Household Level Effects

The reduced form model for copra labor explained 62% of the variation in copra labor across households and time (Table 3-2). Copra price alone had a positive effect on copra labor (β =7.46, Robust SE=6.43); however copra price interacted with the fraction of copra labor in 2001 had a negative effect (β =-16.25, SE=8.59). Fish price showed the opposite trend. Overall, the effect of the copra price on copra labor was positive when the fraction of labor in copra in 2001 was low (indicating high

enjoyment of fishing) and negative when the fraction of labor in copra was high (indicating low enjoyment of fishing) (Figure 3-3a).

The reduced form model of fishing labor explained 46% of the variation across households and time and showed the opposite responses to price changes (Table 3-3). Copra price alone had a negative effect on fishing labor (β=-10.07, Robust S.E.=5.21), while the interaction between copra price and the fraction of labor in fishing in 2001 had a positive effect (β=21.46, Robust S.E.=9.28). The effect of fish price was the opposite. The effect of the copra price conditional on the fraction of labor in fishing showed that households with a low fraction of fishing labor in 2001 (indicating low enjoyment of fishing) decreased their fishing labor in response to the copra price increase, while households with a high fraction of fishing labor in 2001 (indicating a high enjoyment of fishing) increased their fishing labor (Figure 3-3b).

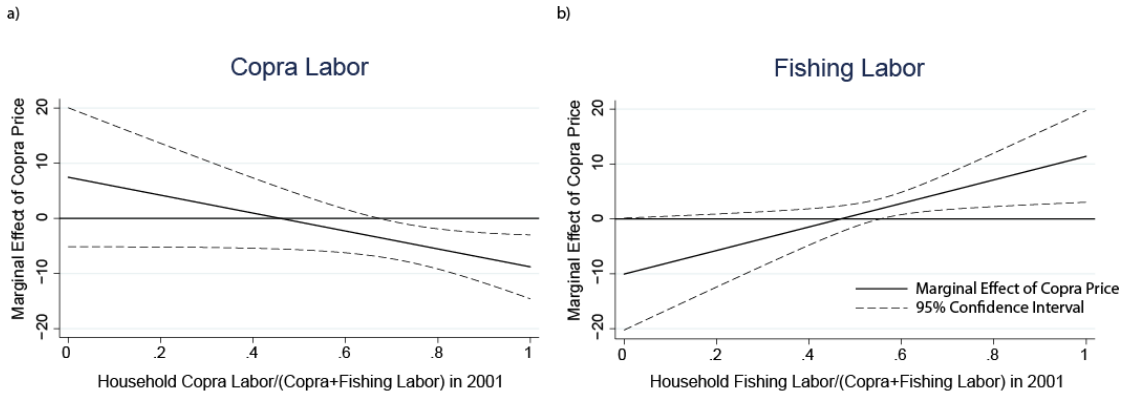

Figure 3-3. The marginal effect of a change in copra price on copra labor (a) and fishing labor (b) conditional on the fraction of labor in copra or fishing in 2001.

Table 3-2. Ordinary least squares estimate of copra labor (log transformed)

Description of explanatory variable	*β*	*Robust SE*
copra price	7.46	6.43
copra price* $\frac{L_{i0}^{c}}{L_{i0}^{c}+L_{i0}^{f}}$	-16.25	8.59
fish price	-12.90	4.30
fish price* $\frac{L_{i0}^{c}}{L_{i0}^{c}+L_{i0}^{f}}$	21.98	4.31
Capital		
bicycles	0.24	0.11
motorcycles	0.45	0.19
gillnet	-0.07	0.10
handlines	0.10	0.06
canoes	0.73	0.44
motor	0.17	0.31
ln(land)	0.99	0.21
Demographics		
number of household members	0.09	0.06
number of males aged 15-60	-0.05	0.08
Constant	-3.32	1.61
N	1872	
R^2	0.62	

Table 3-3. Ordinary least squares estimate of fishing labor (log transformed).

Description of explanatory variable	*β*	*Robust SE*
copra price	-10.07	5.21
copra price* $\frac{L_{i0}^{f}}{L_{i0}^{c}+L_{i0}^{f}}$	21.46	9.28
fish price	5.46	5.33
fish price* $\frac{L_{i0}^{f}}{L_{i0}^{c}+L_{i0}^{f}}$	-8.24	6.34
Capital		
bicycles	0.46	0.17
motorcycles	0.88	0.35
gillnet	0.16	0.19
handlines	0.38	0.26
canoes	0.97	0.51
motor	0.15	0.14
ln(land)	0.36	0.03
Demographics		
number of household members	0.05	0.05
number of males aged 15-60	0.33	0.07
Constant	-6.78	1.88
N	1851	
R^2	0.46	

Aggregate Effects

Labor Allocation

The results of the regression analysis allowed us to estimate the aggregate effects of the copra price change on fishing and copra labor and, ultimately, on the ecosystem. The household specific coefficient on copra price in the fishing labor estimation equation was raised to the population level by an inflation factor (w_{ic}), for household *i* in cluster *c*, by taking the product $\hat{\beta}_i^1 = \left(\hat{\beta}^5 + \hat{\beta}^6 \times \frac{L_{i0}^f}{L_{i0}^c + L_{i0}^f} \right) \times w_{ic}$. The inflation factor is defined as $w_{ic} = h_c \times h_{ic}$, the product of stage specific inflation factors. The cluster inflation factor is defined as $h_c = (n\pi_c)^{-1}$, where n is the number of clusters sampled, π_c is the probability that a cluster is selected ($\pi_c = M_c / T$). The total population, *T*, is the sum of the population in each cluster, M_c, $T = \sum_{c=1}^{N} M_c$. The within cluster inflation factor is defined as $h_{ic} = (m_c \pi_{ic})^{-1}$, where m_c is the cluster sample size, and π_{ic} is the probability a household is selected within a cluster, conditional on the cluster being selected.

The price elasticity of fishing labor then is $e_i^{p^c, L^f} = \hat{\beta}_i^1 \times \overline{p}^c$. Using the estimated price elasticity and the fishing labor in 2003 (the year before the subsidy), we calculated the aggregate change in the fishing labor that would be expected following the price subsidy, $\frac{\sum_{c=1}^{n} \sum_{i=1}^{m_c} \left(17\% \times e_i^{p^c, L^f} \times w_{i,c} \times L_{i,2003}^f \right)}{\sum_{c=1}^{n} \sum_{i=1}^{m_c} \left(w_{i,c} \times L_{i,2003}^f \right)} \times 100$. A 17% increase in the copra price ($p_{2003}^c = 0.47$ AUD 2001/kg, $p_{2004}^c = 0.57$ AUD 2001/kg) resulted in a

33% (95% CI: 81%, -15%) increase in fishing labor. The effect of the copra price subsidy on copra labor was estimated using the same methods and resulted in a -33% (95% CI: -79%, 13%) decrease. Although the percentage increase in fishing labor, 33%, is exactly the same as the percentage decrease in copra labor, 33%, the actual labor reallocation was not identical since the allocation of labor is not evenly divided between copra production and fishing.

Ecosystem Effects

To estimate the effect of a change in fishing labor on the ecosystem, we used parameters from regression models of the relationships between fishing labor and various coral reef ecosystem components (total fish biomass, herbivorous fish biomass, algal cover (turf and macroalgae), and reef-builder cover (coral and coralline algae)) fitted using data from 34 ecological survey sites across an extreme gradient in fishing pressure (caused by a government re-settlement program) in Kiritimati Island, Kiribati. These results, when combined with our economic model, suggest that a 33% increase in fishing labor will result in a 14% decrease in total fish biomass (Figure 3-4a) and a 5% decrease in herbivore biomass (Figure 3-4b). Fishing has indirect effects on reef builders and algae because the consumption of algae by herbivores helps maintain the dominance of reef-builders. We predict that a 33% increase in fishing will result in a 6% decrease in reef-builders (Figure 3-4c) and a 12% increase in algae (Figure 3-4d). The estimate of losses in reef-builders is conservative because increased fishing on Kiritimati only occurred recently and reef-builders are slower to respond to

changes than algae. On historically over-fished reefs, such as in the Caribbean, sudden and almost complete losses of reef-builders have been observed following disturbances (Knowlton 1992, Hughes 1994).

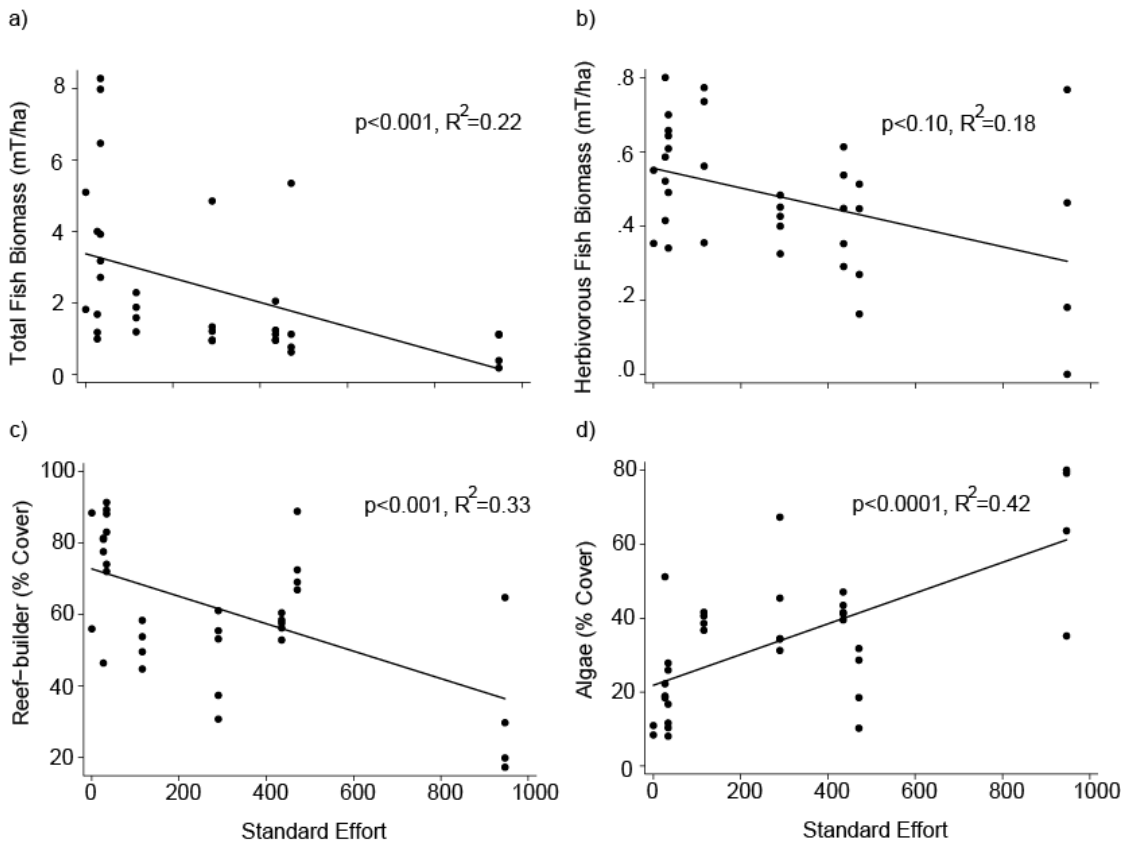

Figure 3-4. Estimates of ecological change in response to change in fishing labor. An estimated 33% increase in fishing labor will result in a) a 1.4% decrease in total fish (B=-0.003, robust SE=0.0009; $F_{1,32}$=13.32, p<0.001, R^2=0.22), b) a 5% decrease in herbivores (B=-0.0003, robust SE=0.0001; $F_{1,33}$=3.26, p<0.10, R^2=0.18), c) a 6% decrease in reef-builders (coral and crustose coralline algae) (B=-0.0004, SE=0.0001; $F_{1,32}$=15.71, p<0.001, R^2=0.33), and d) a 12% increase in algae (B=0.0004, SE=0.00009; $F_{1,32}$=23.62, p<0.0001, R^2=0.42).

We also observed the effect of a change in the copra price subsidy on the

coral reef fishery using responses to a discrete choice question regarding changes in the effort required to catch fish. Of the respondents, 84% (95% CI: 76%, 93%) said that it was getting harder to catch fish, 2% (95% CI: -4%, 7%) said it was easier, and 14% (95% CI: -4%, 23%) said it was staying the same over the study period. Households showed no shift in fishing area or gear over this period, suggesting that changes in the difficulty of fishing represent changes in the resource. In response to a binary choice question regarding the need for fisheries conservation, 91% (95% CI: 72%, 110%) households said that something needed to be done to ensure health fisheries, while only 9% (95% CI: -10%, 28%) said nothing needed to be done.

Welfare Consequences

Welfare necessarily increased with an increase in the copra price (wage), although the gain may be off-set by coral reef degradation in the long-run. To measure the net effect of the copra subsidy on welfare, we used responses to a discrete choice question regarding welfare change over the study period as well as data on ownership of household amenities (tv/video players and non-kerosene or non-candle light sources). We expect that the responses to these questions give a more accurate measure of welfare than income given that non-monetary benefits associated with fishing are important. Of the respondents, 46% (95% CI: 38%, 76%) stated that welfare improved, 43% (95% CI: 27%, 59%) said that welfare did not change, and 11% (95% CI: -12%, 33%) said that welfare declined over the period. The portion of households that experienced declines in welfare typically attributed the decline to

idiosyncratic events, such as deaths in the family, aging, and children leaving home. Households with more fishing labor were more likely to experience declines in welfare ($\beta=0.59$, $p<0.05$), while households with more copra labor were more likely to experience improvements, although this result was only marginally significant. In contrast, households with more fishing labor were more likely to own tv/video players ($\beta=0.86$, $p<0.01$) or have improved lighting ($\beta=0.74$, $p<0.05$). There was no relationship between copra labor and ownership of these goods.

In addition, we asked households if they were satisfied with their income and if they said no, if they wanted some alternative income opportunity. Of the 318 households that responded, 36% (95% CI: 27%, 45%) were satisfied with their income and 64% (95% CI: 55%, 73%) were not. Of the 64% that were not satisfied, 58% wanted some alternative (95% CI: 49%, 67%) and 42% did not (95% CI: 32, 51%). Some respondents gave specific examples of alternative income opportunities, such as selling bread, starting a small company, or improving fishing. Of the 63 households that gave specific examples, 38% (95% CI: 28%, 38%) mentioned something related to improving fishing. Often this was related to capital improvements, such as buying a boat, engine, or new gear, but many households indicated that it was difficult to get a loan unless you were a government employee.

DISCUSSION

We have shown that under standard assumptions, increasing the price of copra should decrease fishing and increase welfare. However, we observed significant

numbers of households actually increasing fishing and decreasing copra labor. To explain these observations, we developed an alternative model in which households also get utility from fishing labor, representing the importance of non-monetary benefits associated with fishing that is often cited by anthropologists. This model predicted that households would increase fishing labor, along with consumption of fish, rice, and other leisure, in response to the copra subsidy. Our empirical estimations support these predictions and show that households that have revealed a high enjoyment of fishing (instrument by the fraction of fishing labor in 2001) increased fishing. In aggregate, the 17% increase in the copra price led to a 33% increase in fishing labor and a 33% decrease in copra labor. The increase in fishing labor was estimated to have significant negative consequences for the fish stock and reef builders, which provide important goods and services such as food or protection from storms and sea-level rise. In sum, the subsidy not only failed to reduce fishing and protect ecosystem services but actually exacerbated the problem. This suggests that although the subsidy had a positive effect on welfare, these improvements will not be maintained in the long-run if the fishery and ecosystem declines.

Although there are other mechanisms that could explain an increase in fishing in response to an increase in the copra price, we find little support for these mechanisms and suggest that role of non-pecuniary benefits of fishing is the most parsimonious explanation. For instance, under the standard assumptions, an increase in copra price should lead to a decrease in fishing and an increase in consumption of all goods, including fish. This suggests that general equilibrium effects could lead to an

increase in the price of fish, which would draw labor back into fishing. However, for the net effect of fishing labor to be positive, this would require the price of fish to increase at a faster rate than the price of copra, which we do not observe, or for rice to be an inferior or even a Giffen good. Given that rice is imported and fish is produced locally, as well as the observation that eating rice is associated with wealth and status, rice is probably not an inferior or Giffen good in Kiribati. Another possible explanation would be a declining fish stock. Although there is some evidence that the fish stocks in Kiribati are declining, the rate of decline is probably much slower than the rate of increase in the copra price and cannot explain the increase in fishing labor over a short time scale.

The limited selection bias, small number of goods, and incomplete labor and resource markets made estimating the effect of the copra subsidy valid and tractable. However, these attributes also limit the generality of the results. Perfect labor markets may buffer responses to alternative income projects because new labor can come in from outside. However, if there were well functioning labor markets in Kiribati, households with lots of land might hire laborers, which would give land owners more free time that they could possibly use to go fishing. Perfect credit markets may strengthen the negative impact of the copra subsidy by enabling households to invest in boats, motors, and fishing gear. Our results suggest that a significant number of households want to invest in fishing capital but are credit constrained. With improved credit markets, fishing labor may not increase, but fishing effort would, with deleterious effects on the reefs. Lastly, there are a very limited number of goods to

purchase or leisure activities in Kiribati. If more options were available, people may substitute fishing labor as leisure for other goods or activities, such as televisions and other mass consumption goods, lessening the negative impact of the copra subsidy.

An additional limitation of the study is the use of re-call data. Evaluating alternative income programs is not only challenging because they often have major issues of selection bias but because data is rarely collected over time. Moreover, the data that is collected must not only include economic data but also ecological and anthropological data. Although the small percentages of households observed changing fishing or copra labor in response to the copra subsidy is inconsistent with our model, suggesting imperfections in the recall data, evidence from island level copra production data suggests that the direction of these changes is correct. Using copra production data over the period 2001-2005 for the four islands surveyed in this study, we found that copra production actually decreased with an increase in the copra price (β=-2064, Robust S.E.=583).

CONCLUSIONS

The results of this research suggest that investments in alternative income programs may not always return a “double-dividend” to conservation and economic development as commonly thought. Non-monetary benefits associated with fishing or other livelihoods may play a significant role and small differences in wages between alternative incomes and fishing may not be sufficient to draw labor out of fishing. Households are likely to respond differently to these programs not only based on their

demographic attributes and capital endowments but based on preferences. Here, we show how a preference for fishing actually causes an alternative income program to have the perverse effect of increasing fishing. In cases where the non-monetary benefits of traditional livelihoods are high, ICDPs need to provide alternative incomes that are similar to the traditional livelihood but have low impact (e.g. catch-and-release sport fishing), make available additional consumption goods, or develop community work programs to produce public or common resource goods.

REFERENCES

Apostle, R.L., Kasdan, L., & Hanson, A. (1985) Work satisfaction and community attachment among fishermen in southwest Nova Scotia. *Canadian Journal of Fisheries and Aquatic Sciences*, **42**, 256-267.

Bennett, E.L. (2002) Is There a Link between Wild Meat and Food Security? *Conservation Biology*, **16**, 590-592.

Berman, M., Haley, S., & Kim, H. (1997) Estimating net benefits of reallocation: discrete choice models of sport and commercial fishing. *Marine Resource Economics*, **12**, 307-327.

Bruner, A.G., Gullison, R.E., Rice, R. E., & da Fonseca, G.A.B. (2001) Effectiveness of parks in protecting tropical biodiversity. *Science*, **291**, 125-128.

Ferraro, P.J., & Kramer, R.A. (1997). Compensation and Economic Incentives: reducing pressure on protected areas. *Last stand: protected areas and the defense of tropical biodiversity* (eds R. Kramer, C. van Schaik, & J. Johnson), pp. 187-211. Oxford University Press, New York.

Gatewood, J.B. & McKay, B. (1990) Comparison of job satisfaction in six New Jersey fisheries: implications for management. *Human Organization*, **49**, 14-25.

Hughes, T.P. (1994) Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science*, **265**, 1547-1551.

Hughes, R., & Flintan, F. (2001) Integrating Conservation and Development Experience: A Review and Bibliography of the ICDP Literature. International Institute for Environment and Development, London.

Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B. J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T. P., Kidwell, S., Lange, C. B., Lenihan, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R.S., Tegner, M.J., & Warner, R.R. (2001) Historical overfishing and the recent collapse of coastal ecosystems. *Science*, **293**, 629-638.

Knowlton, N. (1992) Thresholds and multiple stable states in coral reef community dynamics. *American Zoology*, **32**, 674-682.

Kremen, C., Merenlender, A.D. & Murphy, D.D. (1994) Ecological monitoring: a vital need for integrated conservation and development projects in the tropics. *Conservation Biology*, **8**, 388-397.

Larson, P., Freudenberger, M. & Wyckoff-Baird, B. (1997) *Lessons from the Field: A Review of World Wildlife Fund's Experience with Integrated Conservation and Development Projects 1985-1996*. Final Draft Report.US:WWF, Washington, D.C..

Mora, C., Andrefouet, S., Costello, M. J., Kranenburg, C., Rollo, A., Veron, J., Gaston, K. J., & Myers, R. A. (2006) Coral reefs and the global network of marine protected areas. *Science*, **312**, 1750-1751.

Muller, J. & Albers, H. J. (2004) Enforcement, payments, and development projects near protected areas: how the market setting determines what works where. *Resource and Energy Economics*, **26**, 185-204.

Oates, J.F. (1999) *Myth and Reality in the Rain Forest: How Conservation Strategies are Failing in West Africa.* University of California Press, Berkeley.

OECD. (1996) *Shaping the 21st Century: the Contribution of Development Cooperation.* Organisation for Economic Cooperation and Development, Paris.

Pandolfi, J.M., Bradbury, R.H., Sala, E., Hughes, T.P., Bjorndal, K.A., Cooke, R.G., McArdle, D., McClenachan, L., Newman, M.J.H., Paredes, G., Warner, R.R. & Jackson, J.B.C. (2003) Global trajectories of the long-term decline of coral reef ecosystems. *Science*, **301**, 955-958.

Pollnac, R.B., Crawford, B.R., & Gorospe, M.L.G. 2001. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. *Ocean & Coastal Management*, **44**, 683-710.

Pollnac, R.B. & Poggie, Jr, M.L.G. (1988) The structure of job satisfaction among New England fishermen and its application to fisheries management policy. *American Anthropologist*, **90**, 888-901.

Sanchirico, J. N., Malvadkar, U., Hastings, A., & Wilen, J.E. (2005) No-take zones as optimal fishery management. *Ecological Applications*, 16, 1643-1659.

Sanchirico, J.N., & Wilen, J.E. (2001) Dynamics of spatial exploitation: a metapopulation approach. *Natural Resource Modeling*, **14**, 391-418.

Smith, C.L. (1981) Satisfaction bonus from salmon fishing: implications for economic evaluation. *Land Economics*, **57**, 181-196.

Sievanen, L., Crawford, B., Pollnac, R., & Lowe, C. (2005) Weeding through assumptions of livelihood approaches in ICM: seaweed farming in the Philippines and Indonesia. *Ocean & Coastal Management*, **48**, 297-313.

Smith, D., Hughes, R. & Swiderska, K. (1998) Review of Lessons Learnt from DFID-supported Biodiversity and Livelihoods Development Projects. Unpublished report for the UK Department for International Development. Internet: http://www.iied.org/blg

Thiele, M.T., Pollnac, R.B., & Christy, P. (2005) Relationships between coastal tourism and ICM sustainability in the Central Visayas region of the Philippines. *Ocean & Coastal Management*, **48**, 378-392.

Tisdell, C.A. (1995) Issues in biodiversity conservation including the role of local communities. *Environmental Conservation*, 22, 216-222.

UNDP. (2000) *Proceedings of the Integrated Conservation and Development Projects Lessons Learned Workshop.* UNDP/World Bank/WWF, Hanoi.

Wells, M. P., Brandon, K.E., & Hannah, L. (1992) *People and parks: linking protected area management with local communities.* The World Bank, WWF, and USAID, Washington, D.C.

Wilcox, E.S. (1994) *Lessons from the Field: Marine Integrated Conservation and Development.* World Wildlife Fund, Washington, D.C..

Wilkie, D.S., & Godoy, R.A. (2000) Economics of bushmeat. *Science*, **287**, 975-976.

Worah, S. (2000) International History of ICDPs. *Proceedings of Integrated Conservation and Development Projects Lessons Learned Workshop, June 12-13, 2000.* UNDP/World Bank/WWF, Hanoi.