The interaction between seaweed farming as an alternative occupation and fisher numbers in the central Philippines

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Abstract

Alternative occupations are frequently promoted as a means to reduce the number of people exploiting declining fisheries. However, there is little evidence that alternative occupations reduce fisher numbers. Seaweed farming is frequently promoted as a lucrative alternative occupation for artisanal fishers in Southeast Asia. In this chapter, we examined how the introduction of seaweed farming has affected village-level changes in the number of fishers on Danajon Bank, central Philippines, where unsustainable fishing has lead to declining fishery yields. To determine how fisher numbers had changed since seaweed farming started, interviews were conducted with the heads of household from 300 households in 10 villages to examine their perceptions of how fisher numbers had changed in their village and the reasons they associated with these changes. Key informants (people with detailed knowledge of village members) were then asked to estimate fisher numbers in these villages before seaweed farming began and at the time of the survey. We compared the results of how fisher numbers had changed in each village with the wealth, education, seaweed farm sizes, and other attributes of households in these villages, which were collected through interviews, and with village-level factors such as distance to markets. Respondents were also asked why they either continued to engage in or ceased fishing. In four villages, respondents thought seaweed

farming and low fish catches had reduced fisher numbers, at least temporarily. In one of these villages, there was a recent return to fishing due to declines in the price of seaweed and increased theft of seaweed. In another four villages, fisher numbers increased as human population increased, despite the widespread uptake of seaweed farming. Seaweed farming failed for technical reasons in two other villages. The results suggest seaweed farming has reduced fisher numbers in some villages, a result that may be correlated with socioeconomic status, but the heterogeneity of outcomes is consistent with suggestions that alternative occupations are not a substitute for more direct forms of resource management.

Introduction

Unsustainable fishing may be better predicted by development status and access to markets than by human population size (Cinner & McClanahan 2006; Cinner et al. 2009b; Kronen et al. 2010). Nevertheless, finding strategies that successfully reduce fisher numbers in developing countries remains a key concern for fisheries managers and policy makers (Salayo et al. 2008; Torell et al. 2010).

The development of alternative occupations (i.e. non-fishing occupations) is frequently promoted as a means to reduce fisher numbers in developing countries (Salayo et al. 2008). This approach is often based on the assumptions that fishers fish because they have no alternative occupations (see Béné 2003) and that fishers will replace fishing with more lucrative alternative occupations if they are available (Sievanen et al. 2005). These assumptions ignore increasing evidence that the rural poor often pursue a diverse range of occupations to reduce risk and uncertainty in meeting their livelihood needs (Ellis 2000a; Barrett et al. 2001; Allison & Ellis 2001). Furthermore, the rural poor may fish for noneconomic and economic purposes (Pollnac et al. 2001b); thus, they may fish even when alternative occupations are available.

The importance of livelihood diversification is recognized in the sustainable livelihoods approach to poverty reduction, which promotes the development of alternative occupations as a complement to rather than a replacement for fishing (Allison & Horemans 2006). Diversified livelihoods could allow households to respond to periods of low fish abundance by reallocating labour elsewhere (Allison & Ellis 2001). Empirical research under hypothetical scenarios suggests fishers with greater access to alternative occupations may be more willing to stop fishing sooner as catches decline (Cinner et al. 2009a).

Few studies provide empirical evidence of the effect of alternative occupations on fishing levels, and those that do focused on individual-level fishing effort. Interviews with Southeast Asian fishers reveal that in some places individuals have ceased fishing after starting seaweed farming , but in other places individuals who have started seaweed farming continue to fish at the same level (Sievanen et al. 2005). In Kiribati fishers' individual-level effort varies in response to a program that subsidizes cultivation of coconut, but the average fishing effort has increased, mainly for noneconomic reasons such as enjoyment of fishing (Walsh 2009). Because new people may enter the fishery as others cease fishing, there is a need to understand the changes in total fisher numbers and to understand when and why the availability of alternative occupations may result in reduced fisher numbers.

We sought to explore the village-level effects of an alternative occupation on fisher numbers. Implementation of alternative occupations rarely includes evaluation (Walsh 2009), so post hoc assessments are often required. In the absence of baseline data, one approach is to draw on people's memories to establish retrospectively the effect of an intervention (e.g. Salafsky & Margoluis 1999). We analyzed the effect of seaweed farming on fisher numbers in 10 villages on Danajon Bank, central Philippines. The number of fishers does not directly reflect fishing intensity, which results from the number of fishers and their fishing effort and technology within a defined area. However, robust measures of effort are difficult to obtain due to the diversity of fishing methods used on Danajon Bank and the technological changes that have occurred in recent decades (Green et al. 2004). Changes in fisher numbers reflect reallocations of labour, can be compared to the expected responses of fishers to declining catches (Cinner et al. 2009a), and are of interest to managers and policy makers (Salayo et al. 2008).

We examined whether seaweed farming has affected trends in fisher numbers in these villages and why people have chosen to continue or cease fishing. We then explored socioeconomic and seaweed-farming factors that may correlate with different outcomes. Fishing effort on Danajon Bank is unsustainable and catches have declined considerably in recent decades (Green et al. 2004; Christie et al. 2006; Armada et al. 2009). The human population near Danajon Bank has increased in recent decades (Armada et al. 2009), which in the absence of many alternative occupations to fishing will likely lead to an increase in fisher numbers. On the basis of this reasoning and information in the literature (Allison & Ellis 2001;

Cinner et al. 2009a), we hypothesized that fisher numbers decreased or stabilize after seaweed farming started as labour was reallocated to seaweed farming.

Methods

Site description

Danajon Bank is a good study site for three reasons. First, it is a double barrier reef that stretches approximately 130 km between Bohol and Cebu provinces (Chapter 2, Fig. 2.1), so it is a relatively small and discrete area where fish stocks are shared among 17 municipalities (Armada et al. 2009). All resource users face similar resource conditions, and because human population densities are high, they are highly dependent on coastal resources and have few alternatives to fishing and seaweed farming (Armada et al. 2009). Second, the area comprises 40 small islands, each with associated villages. Each village has its own governance structure and elected officials and falls within the jurisdiction of a municipality that is responsible for the governance of marine resources. Seaweed farming was introduced in these villages at different times (from 1960s to 2008) and in a variety of ways, so the villages can be considered independent experimental units. Third, seaweed farming can be a lucrative endeavour for artisanal fishers in the region because start-up costs are low (Hurtado et al. 2001; Sievanen et al. 2005) and global demand for the hydrocolloids that are extracted from seaweed outstrips supply (Bixler & Porse 2011). Thus, there is growing interest in seaweed farming locally (Armada et al. 2009) and globally as a means to diversify livelihoods and reduce dependence and pressure on declining fisheries.

Ten villages were selected for this study, distributed along the length of Danajon Bank, two from each of five municipalities within Bohol Province: Bilangbilangan and Batasan (Tubigon), Cuaming and Hambungan (Inabanga), Handumon and Alumar (Getafe), Mahanay and Guindacpan (Talibon), and Bilangbilangan East and Hingutanan East (Bien Unido). These villages were small (in 2007 5-300 ha and 563-2,848 people) with high population densities (>1,000 persons km^{-2}). All villages were <20 km from the nearest market town, where there were weekly fish markets, and 20-65 km from Cebu City, where there were commercial factories that process dried seaweed into hydrocolloids for export (Chapter 2, Fig. 2.1). The most common income sources outside fishing or seaweed farming included selling food (e.g.

from a produce stand) or water, independent trade (e.g. carpentry or mechanical), remittances sent by family members working in urban areas, and public service (e.g. village police or councillor).

Effect of seaweed farming on fisher numbers

Fieldwork was conducted between November 2008 and May 2009. To examine how seaweed farming has affected fisher numbers, we applied a four-stage approach. First, focus-group discussions were conducted with village and People's Organisation (community organisations) representatives to record the history of seaweed farming in their village, including how and when seaweed farming started. The year seaweed farming started was defined as the year from which seaweed had been consistently farmed by villagers.

Second, a systematic sampling design (every n^{th} household) with a randomized start point based on the latest census list (2008/2009) was used to select 30 households from each village (5-27% of the households in a village). Respondents were heads of household or primary income earners; often husband and wife were interviewed together (162 women and 291 men). Respondent's perceptions of changes in fisher numbers in their villages were recorded on timelines, a graphic for recording and analyzing information (Bunce et al. 2000). Key events in respondent's lives (marriages and birth of children) and within the village were used as memory aids and to orient respondents to the timeline. Respondents were asked about changes in fisher numbers, which were indicated on the timeline (e.g. positive slope represents increasing fisher numbers). Respondents were free to choose the time intervals they felt appropriate for these changes and were not constrained to discussing changes in relation to the onset of seaweed farming. Respondents were then asked why these changes had occurred and noted their responses on the timeline (Supporting Information). Information was also gathered on the respondent's involvement in fishing (current fisher, ceased fishing, or never fished). Analysis of variance was used to examine whether there were differences between villages in the number of years that respondents could recall.

The proportion of respondents that said the number of fishers increased, decreased, and did not change was calculated per village for each year for which more than one respondent provided information. These proportions were interpreted as the strength of belief in how fisher numbers had changed. Villages were categorised as having decreased or increased numbers of fishers on the basis of the majority consensus on the dominant trend in fisher numbers since seaweed farming started (Fig. 1). To examine potential sources of disagreement in perceived trends (e.g. shifting baselines; Pauly 1995), Fisher's exact tests were used to analyse the association between respondents experience and their responses. The measures of experience we examined included a respondent's baseline year (first year of their timeline) relative to the year seaweed farming began (before or after seaweed farming started for villages where seaweed farming started after 1980 and before or after 1980 for villages where seaweed farming started before 1980) and the respondent's involvement in fishing (given above).

On the basis of a cursory examination of the full data set, reasons given for changes in fisher numbers were placed into one of six categories: seaweed farming (people substituted fishing with seaweed farming); reliability of fishing income; human population growth; lack of employment options; problems with seaweed farming (e.g. theft); seaweed farming in addition to fishing; other (reasons that did not fit into any of the other categories). For the years after seaweed farming started, we tallied the number of respondents per village citing each of these reasons for each direction of change. Respondents could indicate different directions of change at different times and multiple reasons for these changes.

Third, to supplement the information from timelines, key informants (people with detailed knowledge of village members) from each village recalled and listed (with the aid of census information) all the households in their villages and which of these households had a head of household engaged in fishing or seaweed farming. Due to time constraints, this information was only collected for the year before seaweed farming started (fishing only) and 2008 in each village. Because the availability of census information varied among years and villages, key informants were asked to focus on whether a head of household was involved in fishing or seaweed farming rather than total numbers of fishers or seaweed farmers. Between four and 12 key informants per village were involved in this exercise, depending on the size of the village, the number of households that key informants could recall, and census information available. Key informants were selected on the basis of their knowledge of the households and their occupations through peer recommendations and discussions with village leaders, and they were fishers and seaweed farmers that had been resident in the village most of their lives, including the period of interest. At least one of the key informants from each village had held official positions in the village, such as health worker, that required good knowledge of the households and their livelihoods (Supporting Information).

Fourth, to help explain differences in the effect of seaweed farming on fisher numbers among villages, the systematic household surveys were also used to collect information on basic socioeconomic attributes of village members that could influence livelihood strategies (Allison & Ellis 2001), including wealth, household size, education, income levels, and other sources of household income for all interviewed households, size of seaweed farms, training from a seaweed farming technician, membership in a People's Organisation relevant to seaweed farming, source of start-up capital (personal or external, such as government or investor), and satisfaction with seaweed productivity for households involved in seaweed farming. Wealth scores were based on principal components analysis of household structure and possessions, and these scores ranged from -2.91 (poorest) to 7.33 (wealthiest) (Chapter 2, section 2.5). Data were also gathered on factors that influence "livelihood landscapes" (i.e. a "set of occupations and their interrelations") (Cinner & Bodin 2010), including village distance to markets and population size, from secondary sources, including maps, national population censuses, and village profiles held by village officials (Supporting Information).

To allow for the hierarchical sampling design, mixed-effects models were used to determine whether there were differences in socioeconomic status and seaweed farming factors between villages where fisher numbers increased and villages where fisher numbers decreased. Mixed-effects models enabled the within-village error to be partitioned from the residual error; thus, we avoided the problem of non-independence of errors (Bolker et al. 2009). The likelihood ratio test was used for mixed-effects models to calculate p values for differences between villages where the number of fishers increased and villages where the number of fishers decreased, using the lme4 package in R (Bates et al. 2011). We used t-tests to examine whether there were differences in village-level variables between the two types of villages.

Reasons for continuing or ceasing to fish

To address why people continue or cease fishing, respondents from the surveyed households that were involved in or had ceased fishing were asked to rank a list of reasons why they engaged in or had ceased fishing and to provide other reasons not included on the list. The list of reasons was generated on the basis of pilot studies we conducted in these villages (Supporting Information). The importance of each reason was scored as an integer from 0 (not important) to 3 (very important).

Results

Effect of seaweed farming on fisher numbers

The year that seaweed farming started in each village ranged from 1962 (Hingutanan East) to 2008 (Batasan) (Fig. 1). Seaweed farming was introduced to villages through encouragement by the hydrocolloid industry (Hingutanan East and Bilangbilangan East), transfer among villages by residents who had seen seaweed farming in operation elsewhere (Handumon, Cuaming, Guindacpan, Hambungan and Alumar), and government assistance programs (Mahanay and Batasan). In Hingutanan East and Bilangbilangan East, the hydrocolloid industry initially established large seaweed farms and employed village members to work on those farms. Seaweed farmers from Hingutanan East subsequently established their own farms, whereas most seaweed farmers from Bilangbilangan East continued to work on farms owned by the hydrocolloid industry or by individuals from Hingutanan East and to collect wild seaweed. All villages received government assistance (Fig. 1) and had access to training facilities and technicians. Government assistance took the same form in all villages and was composed of start-up capital distributed to individual members of People's Organisations in the form of seedlings and equipment and some basic training in seaweed-farming methods. Seaweed farming was not established in Bilangbilangan Tubigon because disease killed early crops and later seedlings died during transport to the island. Focus-group discussions indicated that prior to seaweed farming, fishers in Alumar and Mahanay struggled to cope with declining fish catches because they could not change their fishing methods in order to target other fisheries. Bilangbilangan Tubigon and Batasan were excluded from analyses because there was no seaweed farming in these villages for more than a year before the study was completed.

Most respondents were able to recall periods of 10-40 years (mean [SD] = 26.3 years [13.24]), and there was no significant variation among villages in number of years recalled (analysis of variance, $F=1.46$, $df=9$, $p=0.16$). In four villages the majority of respondents perceived continued increases in fisher numbers after seaweed farming was introduced (Fig. 1) and associated the increase with population growth and lack of other employment options (Table 1). The high number of respondents that said they had no other employment options indicates seaweed farming was not perceived as a potential alternative to fishing, despite the fact seaweed farming had started in these villages. Respondents' comments indicated fishing provided the primary source of income for daily household requirements. Although not a

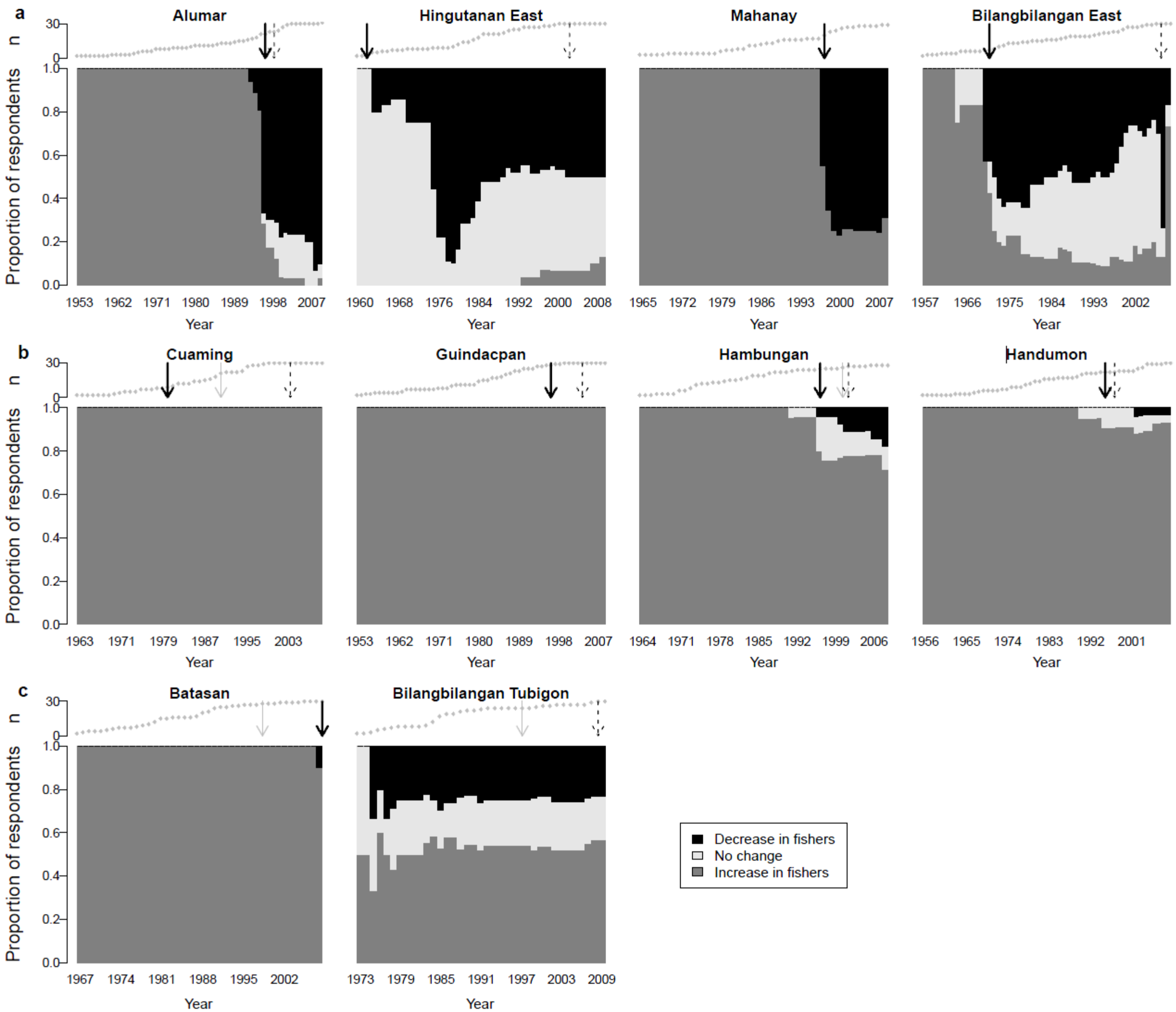

Figure 1. Perceived changes in fisher numbers by village from the extensive surveys in 10 villages: (a) decrease in number of fishers, (b) increase in number of fishers, and (c) villages where seaweed farming had not been going for more than 1 year. The bottom and largest portion of graphs shows proportion of respondents that perceived each direction of change in the number of fishers per year. Dotted lines at the top of each graph show the number of respondents (*n*) that referred to each year (minimum 2, maximum 30). Bold arrows indicate when seaweed farming became established; dashed arrows indicate when a government assistance program for seaweed farming was initiated; and grey arrows indicate other forms of seaweed farming introduction. Where dashed arrows are missing it is because the assistance program coincided with the onset of seaweed farming.

direct reason for fisher numbers increasing, 17% of respondents from villages where number of fishers increased indicated seaweed farming was additional to fishing rather than a substitute because it provided sporadic income that was useful for nondaily household needs such as buying clothes, school fees, or house maintenance.

In four other villages, the majority of respondents (maximum 73-93% of respondents per village per year) perceived decreases in fisher numbers after seaweed farming started, and seaweed farming was perceived as the main factor associated with reductions in numbers of fishers (Table 1).Relatively few respondents from these villages per year reported further increases in numbers of fishers in subsequent years, except in Bilangbilangan East, where in the year preceding the study perceived changes in fisher numbers changed abruptly from 73% of respondents indicating fisher numbers decreased to 73% indicating fisher numbers increased within a year (Fig. 1). Reasons given for this sudden perceived change centred around a global surge in seaweed prices in early 2008, which caused people to move into seaweed farming and out of fishing. This was followed by increased incidence of seaweed stealing and a rapid reduction and stabilization in the price of seaweed, which resulted in people moving out of seaweed farming and into fishing. These price fluctuations were reported in all villages, but only had a detectable effect in Bilangbilangan East.

Not all respondents in villages where number of fishers decreased agreed on directions of change in fisher numbers per year, but disagreements were generally not associated with experience. In Alumar the only respondents that reported increases in number of fishers after seaweed farming started (n=7) were those with a baseline before seaweed farming started (n=24), which resulted in an association between baseline year and perceived changes in number of fishers (Fisher's exact test, $p<0.05$). However, all of these respondents also reported decreases in number of fishers as well. There was no association between experience variables and perceived changes in fisher number in any other villages where number of fishers decreased (Fisher's exact tests; baseline year, Mahanay $p=0.68$, Hingutanan East $p=0.09$, Bilangbilangan East $p=0.83$; fisher status, Alumar $p=0.70$, Mahanay $p=0.80$, Hingutanan East $p=0.47$, Bilangbilangan East, $p=1$).

Table 1. Number of respondents perceiving change in fisher numbers since the onset of seaweed farming and the reasons for the changes.

	Villages with decreased number of fishers				*Villages with increased number of fishers*			
Change in fisher numbers and reasons for change	*Alumar*	*Hingutanan East*	*Mahanay*	*Bilangbilangan East*	*Cuaming*	*Guindacpan*	*Hambungan*	*Handumon*
Decrease*	**28**	**15**	**22**	**26**	**0**	**0**	**5**	**1**
declining fish catches	9	5	3	11	0	0	1	1
seaweed farming	26	10	22	22	0	0	5	1
other	0	0	0	1	0	0	0	0
Increase*	**7**	**4**	**14**	**24**	**30**	**30**	**23**	**28**
fishing income reliable	0	0	3	1	3	4	3	5
human population growth	1	3	6	4	27	27	15	21
no other employment options	2	0	2	3	14	12	11	18
seaweed farming unreliable	1	1	3	19	1	1	2	0
seaweed farming additional to fishing	0	0	0	1	11	0	6	3
other	0	0	0	1	0	1	0	1
No change*	**6**	**22**	**0**	**21**	**0**	**0**	**7**	**2**
declining fish catches	0	6	0	1	0	0	1	1
fishing income reliable	1	1	0	1	0	0	0	0
human population growth	0	1	0	2	0	0	1	1
seaweed farming	3	7	0	6	0	0	5	1
seaweed farming additional to fishing	4	0	0	12	0	0	1	0
other	0	0	0	0	0	0	0	1

* The number of respondents that indicated this change in number of fishers for any year since seaweed farming started. Respondents could indicate different trends in fisher numbers for each year since seaweed farming started, so the values do not sum to 30 (maximum sample size per village) within each village. Each of these respondents could also indicate multiple reasons for each change.

Key informant estimates indicated that involvement in seaweed farming was high in all villages (30-95% of households) (Fig. 2). Key informant estimates showed substantial growth in the total number of households since seaweed farming started (2-6%/year) in all villages except Guindacpan (1.0%/year), with the largest increases in Alumar (5.8%/year) and Hingutanan East (4.2%/year). Key informant estimates showed the proportion of households where heads of household engaged in fishing decreased since seaweed farming started in Alumar, Mahanay, and Hingutanan East (-29% to -64%), but increased slightly (1%) in Bilangbilangan East. The number of households with heads of household engaged in fishing decreased only in Mahanay (-34%) and Hingutanan East (-37%), but increased in Alumar (44%) since seaweed farming started (Supporting Information).

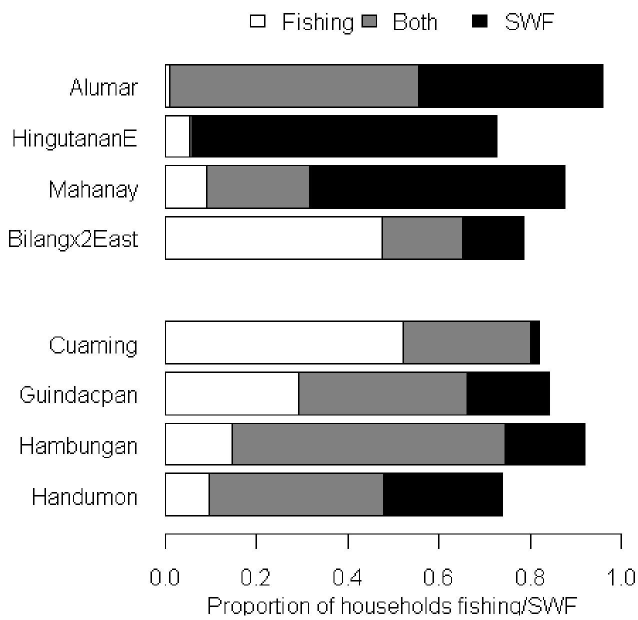

Figure 2. Proportions of all households by village where heads of household were involved in fishing, seaweed farming, or both at the time of the survey: (a) villages where the number of fishers decreased and (b) villages where the number of fishers increased. Data were from estimates made by key informants on the basis of census data (Supporting Information). SWF = seaweed farming.

Socioeconomic factors did not differ between villages with increased numbers of fishers and those with decreased numbers of fishers (Table 2), although it was not possible to test for interactions among variables. Villages where numbers of fishers decreased had both the highest and lowest wealth scores (Hingutanan East, mean [SE] = 1.32 [0.44]; Alumar, -1.02 [0.29]; Mahanay, -0.45 [0.26]) and years of education (Hingutanan East; mean [SE] = 8.25

[0.68], Alumar; 4.55 [0.39], Mahanay; 4.58 [0.34]) (Supporting Information). Two municipalities each contained a village with increased numbers of fishers and a village with decreased numbers of fishers, which suggests governance arrangements such as license fees or regulations did not influence the outcomes. Outcomes were also not consistent with the way seaweed farming was introduced to villages or other village-level variables. Less than 36% of seaweed farmers were members of People's Organisations (through which government assistance programs were administered) or had received technical training in every village except Hambungan (79% members of People's Organisations and 55% received training). Over 80% of seaweed farmers owned their seaweed farms in both village types, except Bilangbilangan East (14%). Seaweed farms were larger in villages where the number of fishers decreased than in villages where the number of fishers increased, and a higher proportion of seaweed farmers in villages where number of fishers decreased used their personal capital for seaweed farming than in villages where number of fishers increased (Table 2).

Reasons for continuing or ceasing fishing

High importance was attached to what local fishers term jackpot – the potential for windfall catches – as a reason to fish (89% of fishers across all villages; n=231) (Table 3). The provision of food and income and the reliability of fishing were considered highly important reasons for fishing by many fishers (70%, 47%, and 56% of fishers, respectively). Lifestyle, tradition, and gear ownership were also considered highly important reasons for fishing by many fishers across all villages (85%, 59%, and 70% of fishers, respectively). A lack of options was considered a highly important reason for continuing to fish by 71% of fishers in villages where number of fishers increased (n=105), whereas 37% of fishers in villages where number of fishers decreased thought this was a highly important reason to continue fishing (n=68).

Seventy-three percent of respondents who had ceased fishing (n=45) were from villages where number of fishers decreased (Table 3). Of these respondents (n=33), 70% assigned high importance to seaweed farming, 55% to declining catches, and 48% to the increasing unreliability of fishing income as reasons for ceasing fishing. Of the 10 respondents who had ceased fishing in villages where number of fishers increased, 20% assigned high importance to seaweed farming and 60% to health or age as reasons for ceasing fishing (Table 3).

Table 2. Summary (mean [SE]) of mean socioeconomic and seaweed farming attributes for members of villages in which the numbers of fishers increased or decreased and for village population and distance to markets for villages of each type.[a] $p<0.001$ = ***, $p<0.01$ = **, $p<0.05$ = *, ns = non-significant

Attribute	*Fishers decreased*	*Fishers increased*	
Socioeconomic factors[b]			
number of other income sources	0.68 (0.11)	0.63 (0.12)	ns
wealth score[c]	0.05 (0.51)	0.07 (0.18)	ns
education of heads of household (years)	5.99 (0.89)	4.79 (0.27)	ns
number of people per household	5.08 (0.21)	5.46 (0.25)	ns
median monthly income – ln(P)	8.73 (0.08)	8.67 (0.13)	ns
Seaweed farming factors[b]			
seaweed farm sizes – ln(ha)	-0.61 (0.26)	-1.66 (0.18)	**
proportion of seaweed farmers with privately owned farms	0.70 (0.19)	0.89 (0.03)	ns
membership of People's Organisation (proportion)	0.21 (0.06)	0.38 (0.14)	ns
personal capital for seaweed farming as opposed to external funding (proportion)	0.75 (0.08)	0.50 (0.05)	*
satisfied with seaweed production (proportion)	0.94 (0.03)	0.93 (0.02)	ns
receipt of technical assistance (proportion)	0.19 (0.06)	0.10 (0.29)	ns
Village[d]			
population size 2007	1,251.5 (342.50)	1,658.0 (526.00)	ns
distance to seaweed market (km)	49.50 (7.27)	31.25 (4.23)	ns
distance to fish market (km)	12.00 (2.12)	8.00 (1.83)	ns

[a] For values by village see Supporting Information.

[b] Socioeconomic factors and seaweed-farming factors were measured for individual households within villages. The mean of these values per village were used to calculate mean (SE) for village types. Significance is based on mixed-effects models that partition the error within villages from the residual error (see text for details). For details of how these factors were measured, see Supporting Information.

[c] Wealth scores were calculated from principal components analysis on household structure and possessions, based on the first principal component which explained 35.2% of the variation among households and ranged from -2.91 (poorest) to 7.33 (wealthiest) (Supporting Information)

[d] Village-level attributes measured once per village.

Table 3. Number of households (n=30) engaged in fishing, ceased fishing, or never fished, and that assigned high importance to the reasons listed for either continuing to fish or for having ceased fishing.

	Fishers decreased				*Fishers increased*				*Other villages*	
Fishing status and reason behind status	*Alumar*	*Hingutanan East*	*Mahanay*	*Bilangbilangan East*	*Cuaming*	*Guindacpan*	*Hambungan*	*Handumon*	*Batasan*	*Bilangilangan Tubigon*
Fishes	**20**	**7**	**15**	**26**	**29**	**24**	**29**	**23**	**29**	**29**
no other employment options	2	3	1	19	24	13	23	15	27	29
enjoyment	11	5	11	21	28	21	23	20	28	29
traditional	14	3	9	21	24	2	17	5	17	25
gear ownership	16	4	8	21	24	12	11	22	24	20
income	0	0	9	0	10	7	16	9	28	29
food	7	3	12	15	27	6	15	20	27	29
reliable	1	2	3	7	28	14	13	9	28	25
jackpot*	17	6	14	23	24	20	26	23	24	29
Ceased fishing	**8**	**12**	**10**	**3**	**1**	**5**	**1**	**3**	**1**	**1**
seaweed farming	6	9	6	2	0	1	0	1	0	0
health / age	3	4	1	1	1	3	0	2	1	1
other livelihood	2	1	3	0	0	3	0	0	0	1
gear loss	1	3	2	2	1	1	0	1	0	0
declining catches	4	6	6	2	0	2	0	1	0	1
income unreliable	5	6	4	1	1	0	0	1	0	1
enforcement of illegal fishing	0	2	3	0	0	0	0	0	0	0
Never fished	**2**	**11**	**5**	**1**	**0**	**1**	**0**	**4**	**0**	**0**

* Potential for windfall catches

Discussion

The results demonstrate the value of timelines as a tool to collect information on historical trends in the absence of formal records. Key informant reconstructions of fisher numbers took a long time to compile, and such reconstructions can mask changes in trends, as was found for Bilangbilangan East. In the other villages timeline results generally were consistent with the results of the key-informant estimates, except for Alumar. The substantial increases in human population size and decreases in the proportion of fishers that key informants estimated for Alumar may have resulted in a dilution effect, which resulted in respondents perceiving a decrease in fisher numbers when they were actually increasing. However, key-informant estimates were based on whether a head of household was involved in fishing, whereas timelines focused on perceived trends in total fisher numbers. It is possible therefore that decreases in fisher numbers occurred through reduced labour allocations to fishing within households in Alumar.

The perceived decreases in fisher numbers associated with seaweed farming and declining catches in the villages where fisher numbers decreased is consistent with how fishers with access to alternative occupations indicate they would respond to reduced catches (Cinner et al. 2009a). The return to fishing in one village where number of fishers decreased as a result of problems with seaweed farming emphasizes the occupational mobility and opportunistic nature of the rural poor (Allison & Ellis 2001) and highlights that people return to fishing when profits from seaweed farming decrease. It is unclear why the declining seaweed prices in 2008 led to returns to fishing in only Bilangbilangan East, but this occurrence may be related to the small proportion of seaweed farms that are owned in Bilangbilangan East. Lower ownership reflects lower capital investment, which is associated with higher mobility among occupations (Smith & McKelvey 1986).

Despite widespread engagement in and institutional support of seaweed farming in villages where number of fishers increased, respondents emphasized that seaweed farming did not provide for daily household needs as effectively as fishing. Results of other studies show that the capacity of fishing to generate nearly instantaneous income (Béné et al. 2009) leads to preferences for fishing over delayed-return occupations such as seaweed farming (Sievanen et al. 2005; Torell et al. 2010). Such preferences suggest that fishing may not be an easily replaced source of income (Smith et al. 2005). This may be especially relevant in areas with limited access to financial services for savings and borrowing and where people may therefore struggle to match infrequent incomes against frequent consumption requirements (Dorward et al. 2009). Additionally, the reasons identified by current fishers for continuing to fish are consistent with other research that finds people fish for both economic and noneconomic reasons (Pollnac et al. 2001b).

Number of fishers were not found to have decreased or stabilized after seaweed farming started in all villages as hypothesized, but instead there was heterogeneity in the changes in number of fishers among villages. The heterogeneity of outcomes found among villages poses a challenge to making simple predictions about the effect of alternative occupations on, and therefore their role in, managing fisher numbers. Seaweed farming is widely supported by government policy in the region. The proportions of people who received such support or training were generally low across villages, indicating any differences in the form of support or training provided would likely have little effect on the changes in number of fishers. Given these findings and that fishers across Danajon Bank faced declining fish catches (Armada et al. 2009), it seems reasonable to expect decreases in number of fishers in each village.

There are two possible explanations for the differences in how number of fishers changed in each village. First, in villages where number of fishers increased, seaweed farms were relatively small and more seaweed farmers used external funding than in villages where number of fishers decreased. The length of seaweed line planted and measures of wealth are positively related in other locations (Sievanen et al. 2005), which suggests constraints on the area available for seaweed farming could affect the profitability of seaweed farming. The use of external funding sources may involve interest payments, possibly in the form of unfavourable price arrangements because traders often provide funding in order to secure cheap and regular supplies (Platteau & Abraham 1987). Such arrangements may reduce the profitability of seaweed farming. However, we could not distinguish between cause and effect because small farm sizes and use of external funding may reflect decisions to invest household resources in occupations other than seaweed farming rather than limited access to suitable seaweed-farming areas or personal capital.

Second, the different outcomes among villages may have been due to the differences in the wealth status of the villages. Livelihood specialization is most likely to occur as part of a “survival” strategy (Smith et al. 2005) or in communities of higher development status (Cinner

& Bodin 2010). Livelihood diversification is otherwise perceived to be the norm when multiple occupations are available (Barrett et al. 2001; Smith et al. 2005). Households from Hingutanan East had the highest levels of wealth and education and Bilangbilangan East was a close second. Both these villages were more specialized in either fishing or seaweed farming than households from other villages, which points to a potential link between specialization and relatively high wealth status.

Households from the other two villages where the number of fishers decreased (Alumar and Mahanay) had the least wealth and relatively low levels of education, and they lacked fishing capital when seaweed farming started. Rapid increases in the local price of fresh fish (1,400% in 20 years) (Green et al. 2004) and increasing access to high-value markets such as the aquarium trade (Christie et al. 2006) may have helped keep fishing economically viable for those fishers who could change target species in response to changes in price and abundance. Such movement of effort among fisheries in response to price has occurred in the Philippines (Fabinyi 2010). A lack of fishing capital of households in Alumar and Mahanay may have prevented them from changing target species, which means switching from fishing to seaweed farming may have been part of a survival strategy. Relatively low investment in fishing assets is typically seen as a strategy to allow opportunistic movement among fisheries and other occupations (Smith & McKelvey 1986). However, a lack of capital assets increases a household's vulnerability to poverty (Allison & Ellis 2001). Thus, seaweed farming, with its relatively low entry costs (Hurtado et al. 2001) and financial support from government assistance programs, may have kept households in Alumar and Mahanay from pursuing occupations with continually decreasing returns (Cinner et al. 2009a).

It remains to be seen whether the measurement of any variables before the introduction of an alternative occupation can help predict effect of that occupation on fisher numbers. Given the array of potential variables that could interact at local and regional levels to determine livelihood strategies (Allison & Ellis 2001), the most relevant variables may be site specific. Our results add weight to the suggestion that alternative occupations may not be a substitute for other resource management tools (Sievanen et al. 2005). However, the development of alternative occupations may help increase support for conservation actions (Pollnac et al. 2001a) and may be useful as a component of an approach that integrates population and coastal resource management (D'Agnes et al. 2010). Our results illustrate the importance of understanding socioeconomic processes when managing the number of people harvesting wild animals.

Supporting Information

Supporting information for this chapter can be found in Appendix, and includes: further details of the methods and results from key-informant estimates (S1), values for household- and village-level variables by village (S2) and, examples of timelines used to collect perceptions on changes in fisher numbers (S3).

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Supporting Information

S1 Key informant estimates of fisher numbers before and after seaweed farming started.

Methods – further information

Key informants included people who had been village health workers, village secretaries (who were responsible for maintaining census lists and recording information such as occupations), People's Organisation (community groups specific to each village) leaders, fishers and seaweed farmers during the year of interest. Normally, key informants held more than one of these posts (i.e. the village secretary was also a fisher and/or seaweed farmer). If key informants were uncertain of household's occupations, they were asked to recommend other key informants that did know of them. Perhaps due to the relatively small geographical area of these villages and the interrelatedness of people from different households, we generally found people to have good knowledge of other households in the village, or at least of the households nearby to them.

Large villages were divided into their respective *puroks* or *sitios* (subdivisions of Filipino villages) and appropriate key informants found for each subdivision. The number of households validated or recalled by key informants varied depending on their knowledge of village members and the level and accuracy (i.e. proximity to the year of interest) of information already available from census lists.

These lists were analysed by calculating the changes in: proportion of households involved in fishing; actual number of households involved in fishing; and total number of households. The number of years since seaweed farming started varied substantially between villages, so all results were standardised per year to enable comparison. Changes in absolute numbers were expressed as compound annual change rates (CACR; Equation 1).

$$(1)\ \text{CACR} = ((\text{Value After} / \text{Value Before})\ \hat{}\ (1 / \text{No. years})) - 1$$

Results- further information

Key informant estimates demonstrate that the proportion of fishers fell substantially in three of the villages were respondents had perceived that number of fishers had decreased (see main text): Alumar (before, 85% of households; after, 56%), Hingutanan East (before, 70%; after, 6%) and Mahanay (before, 68%; after, 32%). In those villages where number of fishers were perceived to have increased (see main text: Handumon, Cuaming, Hambungan and Guindacpan), proportions of households fishing had decreased slightly, but by only 7.9-8.2% (range of starting values; Handumon, 55.6% of households - Cuaming, 88.2%). After controlling for the amount of time since seaweed farming started, Alumar, Hingutanan East and Mahanay showed faster rates of decline in proportion of fishers than villages where number of fishers were perceived to have increased (Fig. S1). In Bilangbilangan East the proportion of households fishing had actually increased slightly (before, 63.8%; after, 65.1%), perhaps primarily as a result of a return to fishing that respondents had perceived (see main text) in 2008.

Since seaweed farming started in each village, the total number of households increased between 115% (Guindacpan) and 733% (Hingutanan East). This represents a cumulative annual growth rate of over 2% for all villages except Guindacpan (Fig. S1). Population growth rate was highest in Alumar and Hingutanan East. Anecdotal reports in Alumar (the highest population growth rate) and Mahanay indicated some residents that had left to pursue work outside these villages had returned, sometimes because of the opportunities of seaweed farming and the way of life. In Hingutanan East, anecdotal reports indicated immigration from terrestrial farmland areas on Bohol was becoming increasingly common.

Despite substantial declines in the proportion of fishing households in Alumar, Hingutanan East and Mahanay, actual fisher numbers only declined overall in Hingutanan East (before, 38; after, 24) and Mahanay (before, 163; after, 107). Controlling for time since seaweed farming started, Mahanay had the fastest decline in fisher numbers (Fig. S1). Alumar showed an increase in fisher numbers (before, 68; after, 98) (Fig. S1).

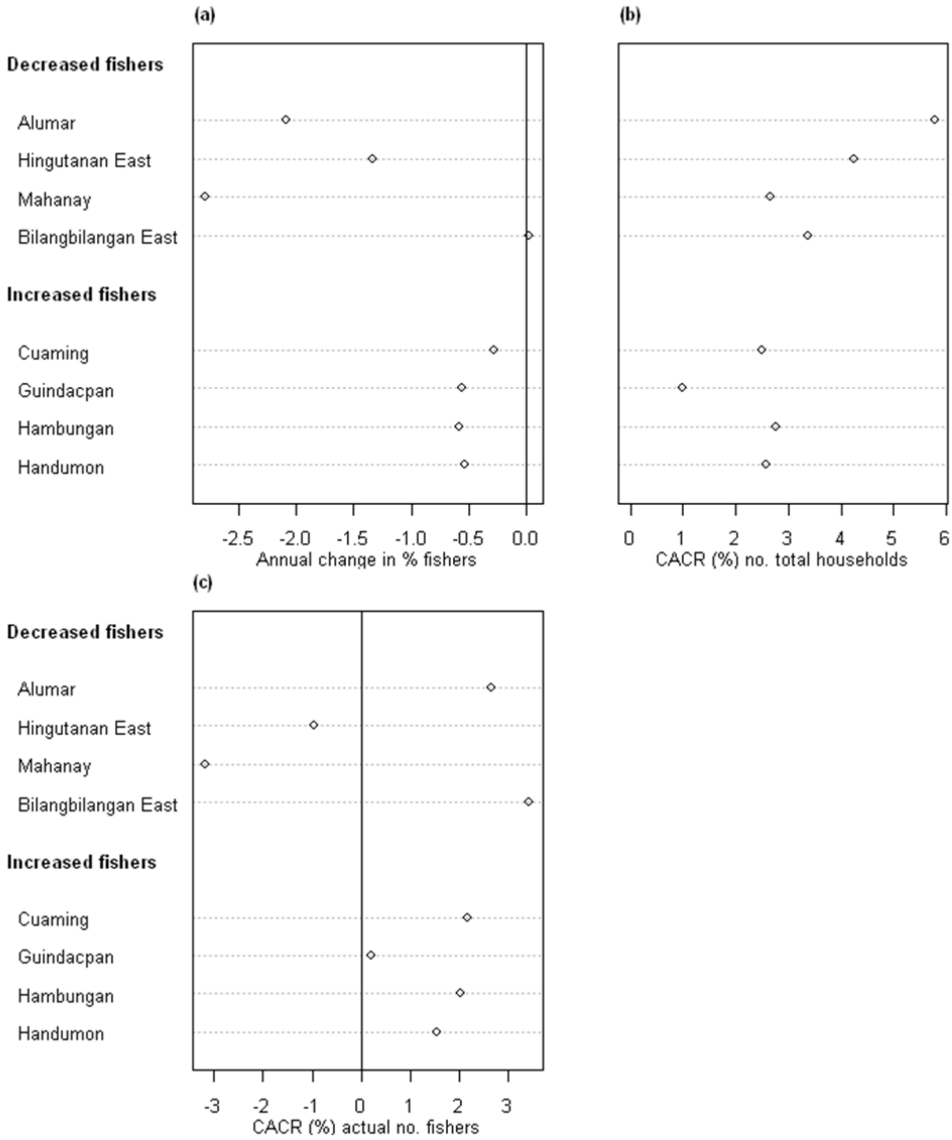


Figure S1 Results of key informant estimates. (a) Annual change in proportion of fishers; (b) annual rate of change of total number of households; (c) annual rate of change of actual number of fishing households. (b) and (c) are expressed as compound annual change rates (CACR). Results are shown for the four villages where respondents perceived decreases in number of fishers, and for the four villages where respondents perceived increases in number of fishers.

S2. Socioeconomic and seaweed farming attributes of households from each village, and village-level statistics.

Socioeconomic attributes collected for all interviewed households included the number of other income sources, wealth score, education, household size and monthly income:

- The number of other income sources was based on occupational categories, and was calculated as the total number of occupational categories outside of fishing (including gleaning) and seaweed farming. Occupational categories included trading of fish/shellfish products; trading of seaweed; agriculture (including livestock, coconuts and arable); salaried employment (e.g. village official or teacher); business (e.g. selling of food or water); casual labouring; handicraft; housemaid; trade of other products (e.g. firewood); independent trade work (e.g. carpentry or mechanical), and; remittances sent by family members living elsewhere.
- Wealth score was based on material style of life scores and ranged from -2.91 (poorest) to 7.33 (wealthiest) (Chapter 2, section 2.5).
- Education was calculated for the heads of households only, and was calculated as the mean number of years that the heads of household had spent in education.
- Household size was the total number of people that live within the household and share their incomes and regularly take meals together.
- Monthly income was the sum of monthly income from all sources of income, estimated for the month prior to the interview. Incomes were recorded in Philippine Pesos (P) and converted to US$ using the 2009 average exchange rate of P47.64 to US$1.

Seaweed farming attributes were collected for all interviewed households that were engaged in seaweed farming, and included size of seaweed farm, whether the household privately owned a seaweed farm, whether any members of the household were a member of a People's Organisation (a community Organisation), whether the household had used their own savings or financial assets to finance the start-up costs of seaweed farming, whether household members were satisfied with seaweed farming production, and whether any members of the household had received any technical assistance or training for seaweed farming. Seaweed farm size was measured in local units (*dupa*, which is equivalent to a fathom), and later converted to hectares. Finance was considered personal if the households own financial capital was used to finance the start-up of seaweed farming, and external if they obtained a loan or government assistance. Satisfaction with seaweed farming was used as a proxy for biological productivity (dissatisfaction indicating that a household's seaweed farming area may not be as suitable for seaweed growth), as time constraints meant we could not measure the growth rate of seaweed in all sites.

Village-level attributes collected included the number of households in the village for the year before seaweed farming started and for 2008 (based on key informant estimates, Appendix S3), population size in 2007 (based on national census data; NSO 2007), and population density, and distance to markets. Population density was calculated from area estimates for each island from village profiles held by village officials and estimation from maps where this was not available. Population densities were placed into categories because multiple and different area estimates were available for each island. The range of population densities estimated fell completely within the category that they were assigned to (1,000-2,000 people km^{-2}, >10,000 people km^{-2}). Distance to market included the distance to the municipal centre where weekly fish markets are held, and distance to Cebu City where the carrageenan producers that buy dried seaweed are based. Straight-line distances were calculated in Google Earth.

Results are presented in Table S2.

Table S2 Socioeconomic (mean (SE), unless otherwise stated) and seaweed farming attributes (counts) of systematically sampled households in each village (n=30 per village), and village level statistics (largest and smallest values within each characteristic highlighted).

	Decreased fishers				*Increased fishers*				*Other*	
	Alumar	*Hingutanan East*	*Mahanay*	*Bilangbilangan East*	*Cuaming*	*Guindacpan*	*Hambungan*	*Handuman*	*Batasan*	*Bilangbilangan Tub*
Socioeconomic										
Other incomes	0.70 (0.15)	0.47 (0.15)	0.57 (0.14)	**0.97** (0.19)	**0.30** (0.09)	0.67 (0.17)	0.90 (0.17)	0.63 (0.14)	0.60 (0.15)	0.47 (0.11)
Wealth score[a]	**-1.02** (0.29)	**1.32** (0.44)	-0.45 (0.26)	0.37 (0.41)	-0.24 (0.17)	-0.17 (0.27)	0.14 (0.29)	0.55 (0.35)	0.08 (0.28)	-0.58 (0.24)
Education; yrs	4.55 (0.39)	**8.25** (0.68)	4.58 (0.34)	6.58 (0.43)	**4.30** (0.31)	4.37 (0.33)	5.38 (0.47)	5.10 (0.39)	6.83 (0.44)	5.43 (0.45)
Household size	**4.70** (0.37)	5.17 (0.46)	4.83 (0.44)	5.63 (0.41)	5.00 (0.34)	**6.00** (0.49)	5.77 (0.41)	5.07 (0.34)	5.03 (0.33)	5.47 (0.29)
Monthly incomes; US$[b] median (range)	136 (19-596)	**176** (32-630)	126 (57-199)	144 (21-504)	**90** (19-220)	126 (42-420)	133 (38-735)	143 (38-924)	126 (63-399)	94 (5-163)
Seaweed farming										
Yr seaweed farming started	1996	1962	1997	1971	1980	1996	1996	1995	2008	NA
n[c]	30	26	30	14	17	17	29	27	13	NA
Size of seaweed farm; ln(ha)	-1.28 (0.18)	**-0.02** (0.13)	-0.60 (0.20)	-0.54 (0.21)	-1.59 (0.26)	-1.48 (0.40)	-2.19 (0.16)	-1.37 (0.27)	**-2.92** (0.40)	NA
Owner of seaweed farm?	27	21	29	2	16	15	27	22	10	NA
Member of People's Organisation?	10	3	3	4	3	4	23	9	3	NA
Personal finance?	16	20	28	11	8	11	12	13	1	NA
Satisfied with seaweed production?	29	24	26	14	16	16	28	24	13	NA
Receipt of training?	3	4	4	5	5	2	16	5	1	NA
Village-level										
# households before seaweed farming	80	54	239	47	289	343	75	133	256	NA
# households after	176	396	336	172	605	394	110	195	262	134
Population 2007	768	1,756	1,919	563	2,848	2,204	568	1,012	959	635
Pop density (km^{-2})	<2,000	>10,000	<2,000	<2,000	>10,000	>10,000	>10,000	<2,000	>10,000	>10,000
Seaweed market (km)	35	63	39	61	22	42	28	33	32	26
Market town (km)	7	16	10	15	12	10	6	4	8	13

[a] Wealth scores are based on material style of life scores (see Appendix S2).

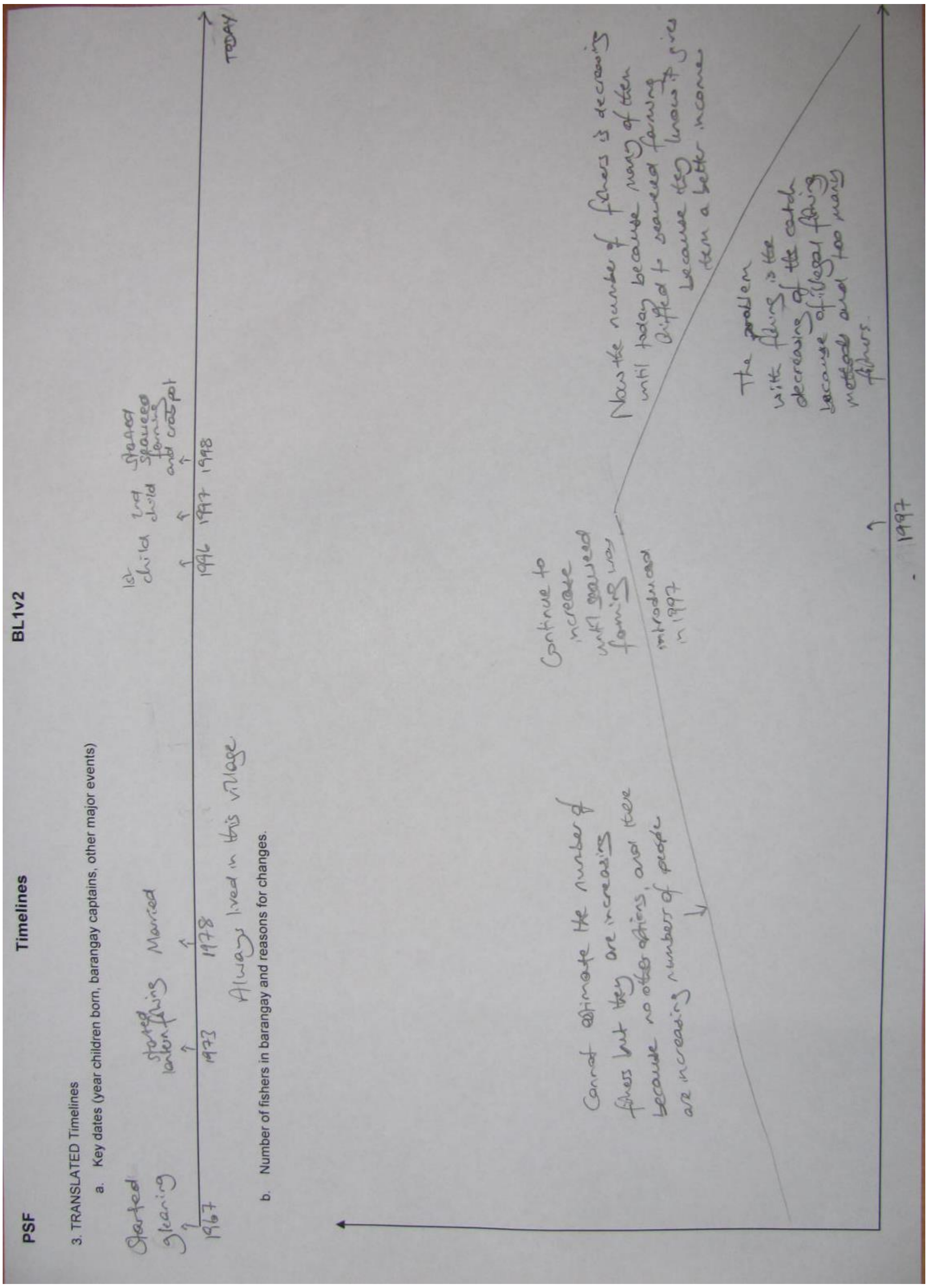
[b] US$ equivalents based on the 2009 average exchange rate of Philippine Peso (PhP) 47.64 to US$1.

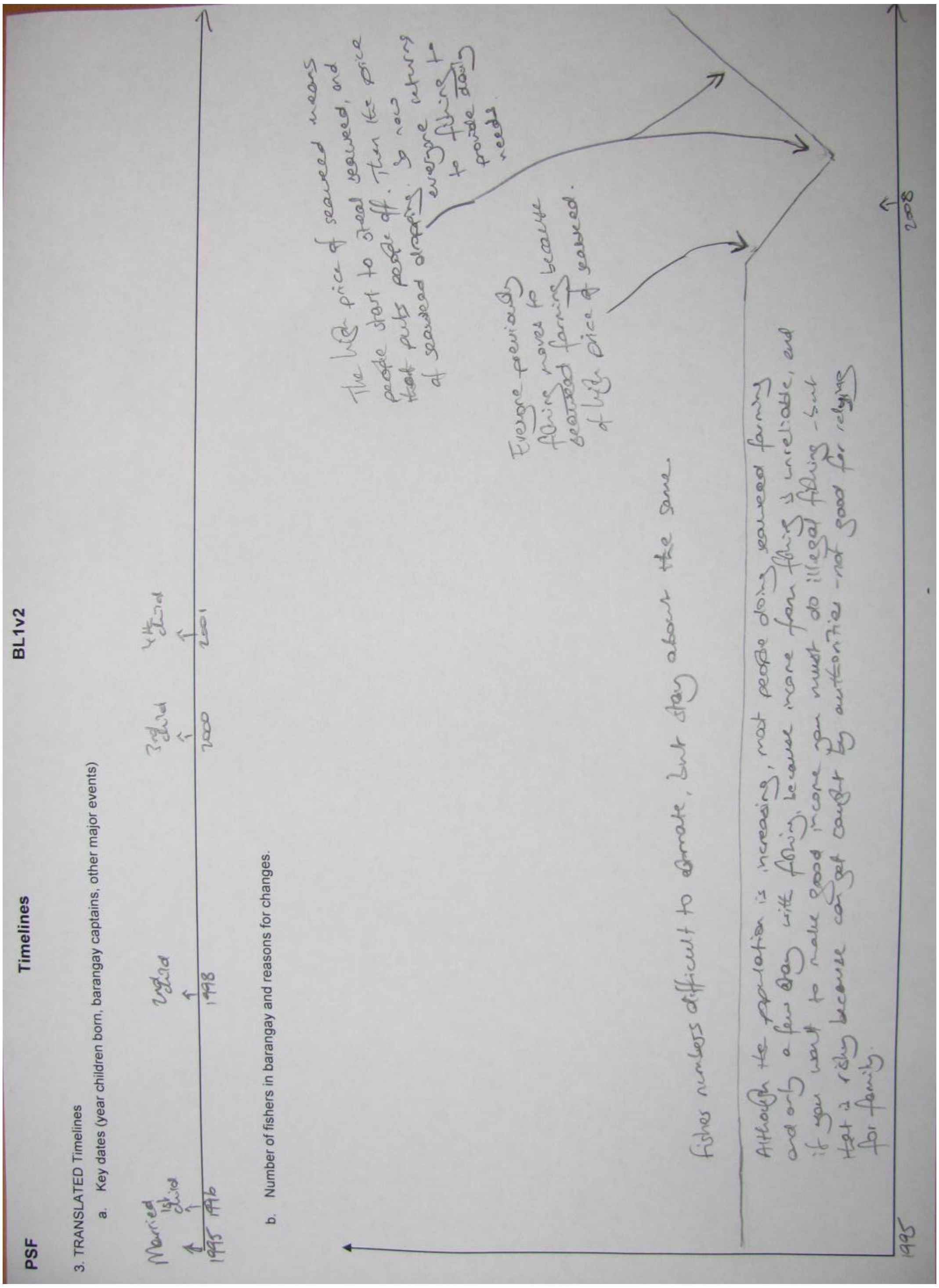
[c] Number of systematically sampled households (n=30 per village) that were currently involved in seaweed farming, and for which seaweed farming characteristics were measured.

References cited for Appendix S2

NSO (National Statistics Office of the Philippines). 2007. 2007 Census of Population. Available from http://www.nscb.gov.ph/activestats/psgc/province.asp?regName=REGION+VII+%28Central+Visayas%29&regCode=07&provCode=071200000&provName=BOHOL accessed 2nd September 2011.

S3. Two examples of timelines used to collect information on perceived changes in fisher numbers.





PSF Timelines BL1v2

3. TRANSLATED Timelines

a. Key dates (year children born, barangay captains, other major events)

Married – 1995
1st child – 1996
2nd child – 1998
3rd child – 2000
4th child – 2001

b. Number of fishers in barangay and reasons for changes.

Fishers numbers difficult to estimate, but stay about the same.

Although the population is increasing, most people doing seaweed farming and only a few stay with fishing, because income from fishing is unreliable, and if you want to make good income you must do illegal fishing – but that is risky because can get caught by authorities – not good for relying for family.

Everyone previously fishing moves to seaweed farming because of high price of seaweed.

The high price of seaweed means people start to steal seaweed, and that puts people off. Then the price of seaweed dropping. So now everyone returns to fishing to provide daily needs.

1995

2008