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Small-scale seagrass fisheries can reduce social vulnerability: a comparative case study

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ABSTRACT

Small-scale fisheries are in decline, negatively impacting sources of food and employment for coastal communities. Therefore, we need to assess how biological and socio-economic conditions influence vulnerability, or a community's susceptibility to loss and consequent ability to adapt. We characterized two Philippine fishing communities, Gulod and Buagsong with similar seagrass and fish species composition, and compared their social vulnerability, or pre-existing conditions likely to influence their response to changes in the fishing resource. Using a place-based model of vulnerability, we used household, fisher, landing and underwater surveys to compare their sensitivity and adaptive capacity.

Depending on the scale assessed, each community and group within the community differed in their social vulnerability. The Buagsong community was less socially vulnerable, or less sensitive to pertubations to the seagrass resource because it was closer to a major urban center that provided salaried income. When we assessed seagrass fishers as a group within each community, we found that Gulod fishers had greater adaptive capacity than Buagsong fishers because they diversified their catch, gear types, and income sources. We found catch that comprised the greatest landing biomass did not have the highest market value, and fishers continued to capture high value items at low biomass levels. A third of intertidal gleaners were women, and their participation in the fishery enhanced household adaptive capacity by providing additional food and income, in an otherwise male-dominated fishery.

Our research indicates that community context is not the only determinant of social vulnerability, because groups within the community may decrease their sensitivity, enhance their adaptive capabilities, and ultimately reduce social vulnerability by diversifying income sources, seagrass based catches, and workforces to include women.

1. Introduction

Food security is critical from local community to global scales (Godfray et al., 2010) (FAO, 2009). Fisheries provide an important source of food protein (Béné et al., 2016) but global demands on fisheries is predicted to increase to 44% by 2030 (Delgado CL, Wada N, Rosegrant MW, Meijer S, 2003), while fisheries catches are declining (Gómez et al., 2006; Jackson et al., 2001; Worm et al., 2009).

Globally, 200 million people are engaged in small-scale fisheries, which are commercial fisheries with limited technology and economic security (De La Torre-Castro and Rönnbäck, 2004; FAO, 2009; McClanahan et al., 2009). 90% of small-scale fisheries are in the developing world, where they provide a labor buffer in situations of unemployment (Allison and Ellis, 2001; Berkes et al., 2001; FAO, 2014). The decline of small-scale fisheries is of critical concern because they supply over half the catch in developing countries (Béné et al., 2007; FAO and World Fish Center, 2008). In developing and emergent countries, fishing is the main livelihood strategy when there are limited alternatives to fishing (Béné et al., 2016). Small-scale seagrass fisheries provide an important food and income source for coastal communities (Campos et al., 1994; Cullen-Unsworth et al., 2014; De la Torre-Castro et al., 2014; De La Torre-Castro and Rönnbäck, 2004; Fröcklin et al., 2014; Khattabi A, 2011; Kleiber et al., 2014; Nordlund et al., 2011; Nordlund and Gullström, 2013; Unsworth et al., 2010, 2014). However, seagrass distribution has declined due to anthropogenic impacts, reducing their ecosystem services (Short et al., 2011; Waycott et al., 2009).

The social vulnerability of communities represents their ability to

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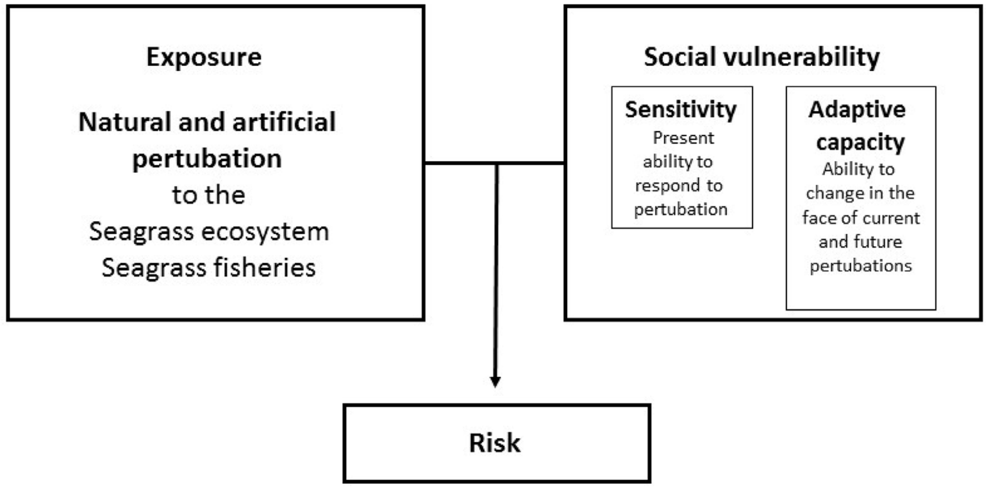

Fig. 1. Conceptual framework used to assess community social vulnerability in the context of seagrass fisheries (Bennett et al., 2014; Cutter et al., 2003; Ekstrom et al., 2015).

resist and recover from exposure events (Buckle et al., 2001; Cutter et al., 2008). Data from fisheries and habitats are critical in assessing vulnerability (UNU-EHS, 2014). Since small-scale fisheries are embedded within complex social-ecological systems, it is important to examine the relationship between social vulnerability and resource use (Berkes et al., 2001; Hughes et al., 2005). First, we need to understand how social and economic development affect income diversity, the ability to cope with crisis, as well as access to markets (Cinner and McClanahan, 2006; Khattabi A, 2011). In small-scale fisheries, poverty is often accompanied by resource degradation (Cinner and Aswani, 2007; McClanahan TR, 2008) and social vulnerability can constrain resource conservation options (Adams et al., 2004). Second, women play an important supportive role in small-scale fisheries and contribute to the household income in times of crisis (Jentoft S, 1999; Kleiber et al., 2015). Often undocumented (Kleiber et al., 2014; Nordlund and Gullström, 2013), women's role in fishing communities can inform adaptive strategies to reduce a community's vulnerability (Beck et al., 2012).

Vulnerability to natural and human-induced hazards has been assessed for coastal communities in the Philippines, but not in a small-scale fisheries context (Orencio and Fujii, 2013). Vulnerability to climate change has been assessed in coral reef and open water fisheries (Mamauag et al., 2013). Here, we present empirical data in a comparative case study assessing social vulnerability in two seagrass fishing communities. We evaluate sensitivity and adaptive capacity and provide specific recommendations to alleviate inherent vulnerability.

2. Methods

2.1. Site description

The Philippines ranks 12th of the capture-fishing nations, with over 1.3 million small-scale fishers (FAO, 2016). In 2010, capture fisheries in the Philippines produced 2.6 million tons, with more than half (1.4 million tons) from small scale fisheries (Asian Development Bank, 2014). 60% of the population lives along the coast, with fish making up 70% of animal protein intake (Asian Development Bank, 2014). Seagrass ecosystems supply important revenue for daily income and other ecosystem services (Campos et al., 1994; Fortes, 2013).

We characterized two small-scale seagrass fishing communities in the Philippines: Buagsong in Cordova, and Gulod in Calatagan (Fig. 2). Buagsong is off Cebu island in the municipality of Cordova, and Gulod is 750 km north on Luzon island in the municipality of Calatagan (Fig. 2). The coastal communities of Buagsong and Gulod have populations of 2,994 and 3,350, respectively. Buagsong is 20 km away from the major metropolitan city of Cebu, with a population of 3.8 million and an international airport, while Gulod is 70 km away from the city of Batangas, with a population of 2.3 million people (Table 2, Fig. 2) (Philippine Statistics Authority, 2016). Philippine municipalities are divided into six classes based on the municipality's average annual income with 1 being highest. Buagsong is in Cordova, a third income class municipality, and Gulod is part of Calatagan, a second income class municipality (National Competitiveness Council Philippines, 2015).

We collected quantitative and qualitative data using underwater surveys, landing surveys, fisher and household surveys, and participant observation, asking similar questions across methods to triangulate information (Cinner et al., 2007), in contrast to vulnerability studies that used rapid assessments, focused group discussions and key informant interviews (Mamauag et al., 2013) or those that mined census data (Orencio and Fujii, 2013).

2.2. Social vulnerability indicators

We use the place-based concept of vulnerability to examine the ability of fishing communities to respond to change (adaptive capacity) and to mitigate their social vulnerability (IPCC, 2012). We view vulnerability in the context of social and environmental processes (IPCC, 2012), and use indicators to measure social vulnerability to better manage risks given underlying socioeconomic conditions and changes to the resource base (Cinner et al., 2009; Jacob et al., 2013; Jepson and Colburn, 2013; Pollnac et al., 2015). We do not evaluate communities with regards to their exposure, or the presence of and extent of stressors, but within the context of their sensitivity, or the degree to which they are affected by the stressor, and their adaptive capacity, or their ability to respond to changes in the seagrass resource base (Marshall et al., 2009). We first described the seagrass ecosystem and fisheries, next we examined community and group sensitivity and adaptive capacity, which combined, contribute to overall risk (Fig. 1). Similar work has addressed the social aspects of fisheries (Jepson and Colburn, 2013), socio-economic responses to natural disasters, changes in fishing practices and regulations, and vulnerability of fishing communities to climate change (Adger et al., 2005; Clay and Olson, 2008; Cutter et al., 2008; González-Correa et al., 2009; Mamauag et al., 2013).

We selected a subset of variables from Jepson and Colburn's demographic, housing, social, and economic indices on social vulnerability (Jepson and Colburn, 2013). We did not quantitatively generate composite indices to rank overall community vulnerabilities from census data (Boyd and Charles, 2006; Jacob et al., 2013; Orencio and Fujii, 2013; Pollnac et al., 2015). We evaluated each community's context, sensitivity and adaptive capacity (Adger, 2006; Bennett et al.,

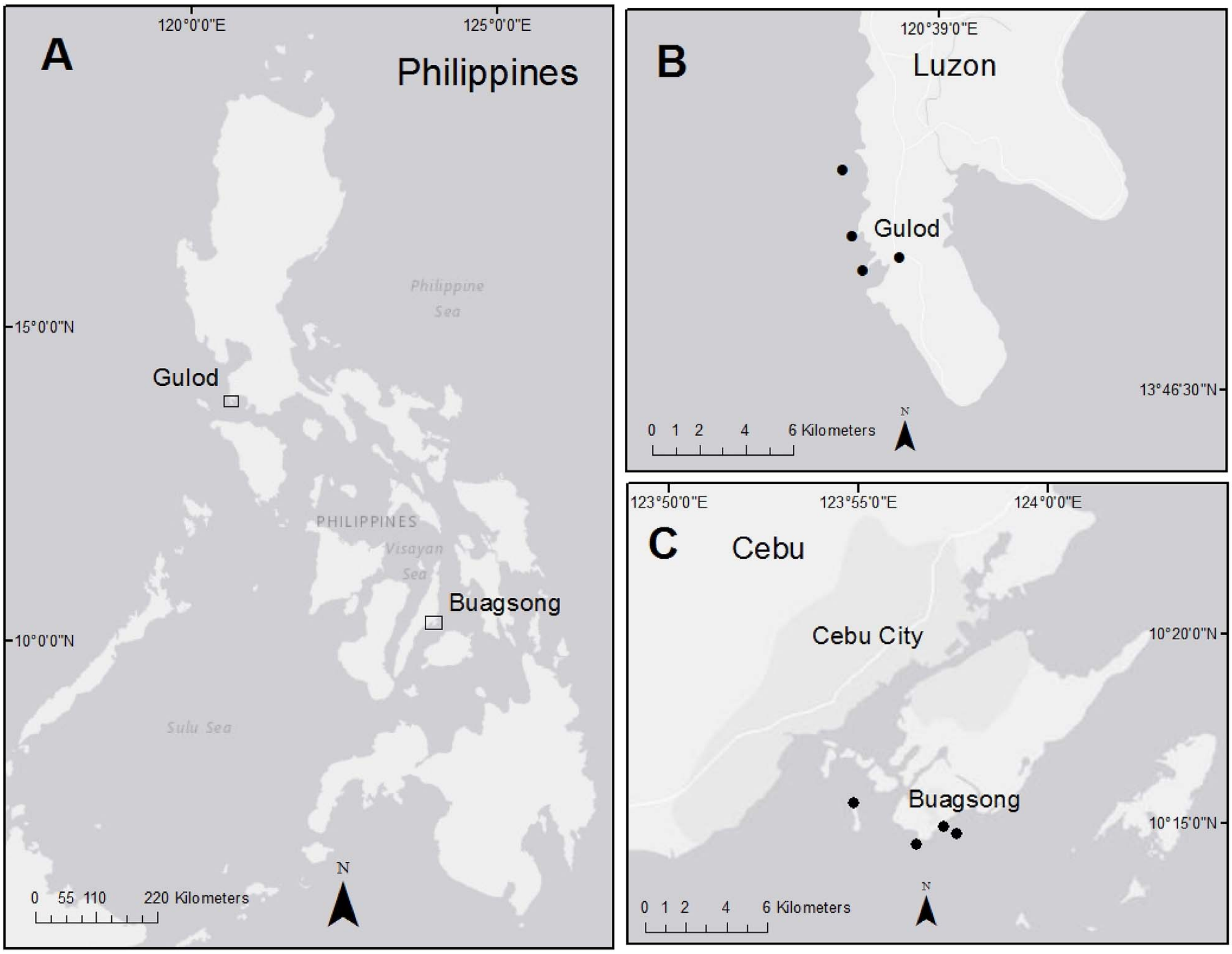

Fig. 2. Locations of **a** the Philippine islands, and the villages and seagrass meadows surveyed in **b** Gulod, Calatagan (Quilitisan Marine Protected Area, and the unprotected seagrass beds of Kambal and the Calatagan pier) and **c** Buagsong, Cebu. (Alegria Marine Protected Area, and the unprotected seagrass beds of Gapas-Gapas Island and Camolinas). *Basemap Source:* World Imagery.

Table 1
Table outlining social vulnerability indicators sensitivity, and adaptive capacity, with associated metrics, and data collection methods.

Sphere	Indicators	Metric	Data collection
Sensitivity	Natural capital indicator	Seagrass meadow characteristics	Ecological survey
		Seagrass fish survey	
		Seagrass catch biomass landed	Landing survey
		Biomass catch kept	
		Seagrass daily earnings	Fisher survey
		Seagrass fishing effort	
		Daily overhead cost of trip	
		Daily value of catch	
	Socio-economic indicator	Household reliance on seagrass resources	Household survey
		Importance of fishing versus gleaning to HH income	Fisher survey
		Quality of life indicator	Household survey
Adaptive capacity	Natural capital indicator	Seagrass catch fish cluster	Landing survey
		Seagrass fishing gear	Landing survey
	Demographic indicator	Proportion women fishers and gleaners	Fisher survey
		Participation by women in fishing and gleaning	Household survey
	Socio-economic indicator	Distance to major city Population of nearest major city	
		Proportion of boat owning fishers	Fisher survey
		Where catch is sold	
		Primary source of HH income	Household survey
		Secondary source of HH income	

Table 2
Comparison of social vulnerability of Buagsong and Gulod grouped to Natural capital, Demographic, Socio-economic indicators *Negative values refer to a greater overhead cost of the trip than cost of the catch. Values shown are means ± SD unless otherwise noted. HH = household. Prop = proportion, Impt = important.

Sphere	Indicators	Metric	Buagsong	Gulod
Sensitivity	Natural capital	Total aboveground seagrass biomass/m^2	4.08 ± 1.17	5.35 ± 3.17
		Shannon-Weiner seagrass diversity index	1.61 ± 0.37	1.72 ± 0.55
		Daily biomass landed (kg)	63.06 ± 24.40	98.50 ± 25.51
		Biomass catch kept (kg)	0.68 ± 0.40	1.0 ± 0.79
		Daily CPUE (kg/hr)	0.79 ± 0.60 (0)	0.91 ± 0.88 (0)
		Landing surveys:	0.84 ± 0.60 (0)	0.84 ± 0.84 (0)
		Fisher interviews:		
		Total daily earnings (US$)	127.88 ± 49.56	164.56 ± 49.07
		Take home income/fisher/day (US$)	5.25 ± 4.75 (−2.67)*	8.84 ± 16.59 (−1.18)*
		Daily cost of trip (US$)	1.83 ± 1.21 (0.07)	0.41 ± 0.89 (0)
		Daily value of catch (US$)	6.65 ± 5.01 (0)	9.82 ± 16.91 (0)
	Socio-economic	Importance of fishing & gleaning to HH income, 1 not impt, 5 very impt (Mdn)	Gleaning: 5 Fishing: 5	Gleaning: 4 Fishing: 5
		Fisher income augmented by	glean (66%), farm (0%), fish selling (10%), other (24%)	glean (22%), farm (22%) fish selling (27%), other (29%)
		Quality of life indicator, between 1 and 10 (Mdn)	3	4
Adaptive capacity	Natural capital	Seagrass catch fish cluster	4 fish clusters	6 fish clusters
		Seagrass fishing gear	4 gear types	5 gear types
	Demographic	Prop. women fishers	15%	13%
		Prop. women gleaners	61%	71%
		Prop. household participation in fishery by: father, wife, children	Glean: 49%, 30%, 20% Fish: 74%, 9%, 17%	Glean: 45%, 37%, 17% Fish: 76%, 4%, 20%
	Socio-economic	Distance to major city	20 km	70 km
		Population of nearest major city	3.8 million	2.3 million
		Prop. boat owning fishers	73%	58%
		Prop. where catch is sold: local, municipal, regional	79%, 21%, 0%	96%, 3%, 11%
		1° source of HH income	salary (76%), fish (24%)	fish (54%), salary (25%), farm (21%)
		2° source of HH income	glean (63%), salary (37%)	farm (65%), salary (21%), glean (7%)

2014; Cutter et al., 2003; Ekstrom et al., 2015; Jacob et al., 2013; Mamauag et al., 2013), measuring natural capital, socio-economic and demographic indicators (Fig. 1, Table 1) (Boyd and Charles, 2006; Cutter et al., 2008; Pollnac et al., 2015; UNU-EHS, 2014).

Data from household surveys measured vulnerability at the scale of the community, while data from fishery landings and fisher surveys measured vulnerability at the scale of the fishers (Buckle et al., 2001) (Table 1).

- **Natural capital indicators**: What fishery resources do seagrass beds provide? Data was collected from fishery landing surveys and ecological surveys (Beck et al., 2012; Cutter et al., 2008; Cutter SL, 1996; UNU-EHS, 2014).
- **Socio-economic and demographic indicators**: Do seagrass fisheries provide essential employment to the communities? Are there differences in a community versus an individual fishers' reliance on seagrass resources? Data was collected from household and fisher surveys (Beck et al., 2012; Boyd and Charles, 2006; Cutter et al., 2008; Cutter SL, 1996; Jacob et al., 2013; Jepson and Colburn, 2013; UNU-EHS, 2014). Are there differences in gender when using seagrass resources? Data was collected from household and fisher surveys (Beck et al., 2012; Cutter et al., 2008; Cutter SL, 1996; Jacob et al., 2013; Jepson and Colburn, 2013; Pollnac et al., 2015).

2.3. Natural capital indicators: seagrass habitat & fisheries

Natural capital indicators described the seagrass resource and associated fisheries (Fig. 1, Table 1). We conducted underwater surveys in three seagrass beds each in the municipal waters of Buagsong and Gulod in July and August 2012. In Buagsong, fish and seagrass beds were surveyed in Day-as reserve in Gapas-Gapas Island, Alegria Marine Protected Area, and Camolinas, an unprotected seagrass bed (N 10.25838, E 123.91478; N 10.24502, E 123.96031; N 10.24837, E 123.95434). In Gulod, fish and seagrass were surveyed in Quilitisan Marine Protected Area, and the unprotected seagrass beds of Kambal and the Calatagan pier (N 13.8601, E 120.61298; N 13.83438, E 120.61685; N 13.82116, E 120.62054) (Fig. 2). Using a modified SeagrassNet methodology (Short et al., 2006), we ran two 50 m transect lines parallel to the shore; the first transect line was in the shallow end of the bed, and the second transect line ran parallel to the first, but 50 m seaward. Along shallow and deep transect lines, we randomly selected ten 0.25 m^2 quadrats, for a total of 20 quadrats sampled per bed. In each quadrat, we identified seagrasses species, estimated total seagrass percent cover and percentage cover of each seagrass species, measured canopy height and shoot length, and shoot density. To sample for aboveground biomass, we collected all shoots from five 0.0625 m^2 quadrats within the ten 0.25 m^2 quadrats per transect line, for a total of 10 biomass samples collected per bed. We separated seagrass shoots by species, scraped off all the epiphytes using a scalpel, oven-dried the seagrass for 24 h at 50 °C, removed the dried seagrass from the oven to check for dryness (if seagrass blades were crisp to the touch) and measured the dry weight. If the seagrass was not dry at the end of 24 h, the samples were returned to the oven for 2 more hours of drying before measuring the dry weight (Table 1).

We used a modified Reef Check method to conduct timed snorkel surveys (10 min duration) to identify fish at the Genus and Species level, if possible, and counted and estimated the length of all fish encountered within 5 replicate, 50 m × 2 m belt transects (Hodgson et al., 2006). We estimated fish biomass using length – weight relationships from FishBase (2015) (Table 1).

We gathered data and engaged in participant observation at 1,062 fisher landings between March 2013 and February 2014 in Gulod (n = 454), and between July and August 2013 in Buagsong (n = 608) (Table 1).

The cool season in the Philippines is *Amihan*, with northeast winds, moderate temperatures and little rain, and lasts between November and May. The southwest monsoon season is *Habagat*, characterized by heat, humidity, and heavy rainfall, and lasts between June and October. Due to logistical constraints, fish landings were observed only in *Habagat* (rainy season) in Buagsong, but we collected fish landings in both *Amihan* (cool season) and *Habagat* (rainy season) in Gulod. Comparisons between Buagsong and Gulod were restricted to data collected during *Habagat* (rainy season), between June and September 2013.

We considered a single fisher landing as what arrived after a single fishing trip; these trips could have been conducted on a boat or from foraging on foot. We recorded all the landings at each landing site for each observation day. We noted the number of fishers on the trip, gear type, date of catch, kilos per catch, habitat where the items were caught, if the catch was sent to the market or for home consumption, and length of the trip. We trained fisher wives and daughters to administer the landing surveys at the landing sites (Appendix Table 1).

We listed local common names of catch and measured the wet biomass of the total catch per landing. We grouped the catch into taxonomic Family groups associated with a local common name. Catch included both fin-fish and invertebrates (Table 4, Appendix Table 8). We did not count nor measure individual catch, so data was limited to a list of catch associated with a single wet biomass value.

2.4. Socio-economic and demographic indicators

We collected socio-economic and demographic data to assess (1) the communities' sensitivity to perturbation, and (2) the communities' adaptive capacity, or assets and capacities that support adaptation (Fig. 1, Table 1).

We administered anonymous face to face surveys to individuals observed to be fishing in seagrass habitats in July 2013 in Buagsong (n = 80) and March 2013 in Gulod (n = 80) (Appendix Table 2) (Campos et al., 1994). The fisher surveys were voluntary and 99% of respondents agreed to do the survey.

We surveyed households in Buagsong in July 2013 (n = 72) and in Gulod in March 2013 (n = 90) to examine the level of dependence on fishing versus salaried employment, family member participation in fishing and gleaning activities, resource use patterns, and socio-economic status (Cinner et al., 2009; Pollnac and Crawford, 2000). Households were defined by a group of people living in the same house and collectively contributing income. In a systematic survey, we selected every fifth house along paved and unpaved roads and spoke to the head of the household present (Appendix Table 3). If a house was empty, we returned to that same house the following day.

We developed a 10-point standard of living indicator based on transportation, communication and utilities (Berkes et al., 2001) (Appendix Table 3). We assessed the importance of seagrass fisheries for households by asking households to rate (1 out of 5) the importance of fishing and gleaning in seagrass beds for subsistence and income, with 1 being not important and 5 being very important.

2.5. Data analysis

We entered data from the fishery landing surveys, fisher surveys, and household surveys into a relational database to link fisher codes with their catch (Microsoft Access).

To compare the seagrass and fin-fish communities from the underwater survey data, we used PRIMER v.6 and created two separate matrices from three replicate beds sampled per site. The first matrix used the average above-ground dry weight biomass of seagrass species m^{-2} and the second matrix used average biomass of fin-fish observed per bed. We used PRIMER v.6 to fourth root transform the seagrass and fin-fish data and created a Bray-Curtis resemblance matrix of the transformed data. We used site (Buagsong or Gulod) as a factor, and tested for differences in seagrass and fin-fish communities separately, using ANOSIM (Anderson and Gorley, 2008; Clarke and RM, 2001). To calculate the dominant fin-fish biomass observed, we summed the mean biomass of all the beds at each site and calculated the proportion of total biomass observed for each Family.

To compare differences in catch, catch biomass and fishery earnings, we used PRIMER v.7 to (1) reduce the multi-species catch from the landing surveys into distinct clusters, and (2) priced each cluster at the local market values of the dominant catch to calculate daily earnings.

Since each landing catch was a multi-species assemblage associated with a single biomass value, we created a matrix with individual fisher landings in rows that include a landing catch identifier, the catch's local common name in columns, denoted each catch with a 1 for presence or 0 for absence, and the associated biomass value for that individual landing. Factors included site (Buagsong, Gulod), gear (fish fences, traps, day and night-time gleaning, encircling gillnets) and date landed. We created separate fisher landing matrices for Buagsong (608 landings over 28 days) and Gulod (454 landings over 24 days), which we imported into PRIMER v.7, created a resemblance matrix based on S1 simple matching, and used the kRCLUSTER routine. We chose the kRCLUSTER routine to specify the number of clusters k for which to assign each landing catch identifier, rather than having that value calculated (Clarke KR, Gorley RN, Somerfield PJ, 2014). Once we assigned each fisher landing catch into distinct clusters, we priced each cluster at the mean market cost of the dominant Families. We considered a Family dominant if it was found in the cluster at least 80% of the time. We calculated daily fisher earnings by multiplying the cost of the cluster with the total biomass caught for that individual fisher landing. To determine which clusters were most important in terms of proportion biomass and value, we compared individual clusters to the total biomass over 28 observation days in Buagsong and 24 observation days in Gulod during *Habagat* (rainy season).

Using JMP Pro 11, we compared fisher catch, number of trips per day and week, trip length, and catch per unit effort, with independent sample t-tests to compare data between the communities from the fisher surveys. To compare differences in ranks from household standard of living indicators, and the ranked importance of fishing to household income and subsistence from household surveys, we employed Mann-Whitney tests.

3. Results

We present data comparing social vulnerability in Buagsong and Gulod, grouped to natural capital, demographic and socio-economic indicators (Table 2).

Seagrass beds in both communities are fringed by coral reefs, seaward and have mangroves landward. In Buagsong seagrass beds extend between 1 and 4 km from the coastline, and in Gulod, seagrass beds extend 1 km from the coastline. In total, we observed six different fishing methods (Table 3). Fish fences ("*baklad*") are enclosures made up of bamboo and fishing net set over seagrass beds, varying in area from 10 to 100 m^2 to catch fin-fish and squid. Metal ("*bubo*") and basket traps ("bantak") are 50 cm long traps to catch crab and eel, respectively. Fishers use 3-m long wooden boats with or without outboard motors to deploy encircling gillnets ("*pamamanti*") to catch fin-fish. Intertidal collecting or gleaning, is walking from shore to gather seagrass fin-fish and invertebrates by hand or with simple tools. Gleaning occurred in the day ("*sikad*") and at night ("*ilaw*"), targeting shellfish, shrimp and other invertebrates (Table 3). Similar to other locations, gleaning requires little or no capital investment because boats were optional, and all community members have access to the intertidal seagrass beds at low tide (Fröcklin et al., 2014; Nordlund et al., 2011; Nordlund and Gullström, 2013; Unsworth and Cullen, 2010).

3.1. Natural capital indicators: seagrass habitat & fisheries

Gulod seagrass beds had greater seagrass abundance (above ground biomass, canopy height, percent cover) and seagrass diversity (Shannon-Weiner diversity index) than in Buagsong (Appendix, Table 4). Seagrass abundance and diversity was highly variable; some

Table 3
Seagrass fishing gear and effort. Summarizes primary gear types, habitats used and effort from seagrass fishers interviewed in two coastal barangays, Buagsong (n = 80) and Gulod (n = 80). Seagrass daily fishing effort is compared for Buagsong (n = 28) and Gulod (n = 24) observed from landing surveys between June and September, 2013. Effort shows mean observed fishers per day (SD).

Gear type	Local name	Primary gear type % in Buagsong (proportion fishers interviewed)	Primary gear type % in Gulod (proportion fishers interviewed)	Effort in Buagsong (number of fishers observed)	Effort in Gulod (number of fishers observed)
Fish fences	*"Baklad"*	0%	15%	N/A	2.92 (1.28)
Metal traps	*"Bubo"*	0%	5%	N/A	3.25 (0.68)
Basket traps	*"Bantak"*	21%	0%	11.46 (4.75)	N/A
Night time gleaning	*"Ilaw"*	42%	25%	4.71 (26.22)	1.54 (1.61)
Daytime gleaning	*"Sikad"*	26%	15%	3.5 (2.33)	2.79 (2.02)
Encircling gill-nets	*"Pamamanti"*	11%	40%	3.19 (1.89)	10.96 (2.79)
Number of boats				N/A	15.33 (2.63)
Number of fishers at landing site				22.86 (9.85)	21.46 (3.19)

beds had 70% seagrass cover and 4 seagrass species, while others had 10% seagrass cover and 1 seagrass species.

There was no significant difference in seagrass community composition (ANOSIM; R = - 0.259, p = 0.80). The only difference between the two sites was the presence of *Cymodocea serrulata* in Gulod (17% cover), which was not found in Buagsong (Appendix, Table 4).

There was no significant difference in community composition from underwater fish surveys (ANOSIM; R = 0.407, p = 0.20); both fishing grounds had Plotosidae, Apogonidae, Labridae, Pomacentridae, Sigandae and Atherindae (Appendix Table 6). Siganidae was most prevalent in Buagsong, while Atherinidae was most prevalent in Gulod. Muraenidae, the main catch in Buagsong, was not recorded in underwater fish surveys of Buagsong, but was recorded in Gulod underwater fish surveys. Conversely, Siganidae, the main catch in Gulod, comprised a minor part of the observations in Gulod, but dominated Buagsong underwater fish surveys (Appendix, Tables 5 and 6).

The total daily mean biomass of seagrass fishery landings was

Table 4
Fish Clusters. Seagrass fisher landings from 28 days in Buagsong (n = 608) and 24 days in Gulod (n = 454), June–September, 2013. PRIMER's kRCluster analysis assigned each landing to clusters in Buagsong (n = 4) or Gulod (n = 6).

Site	Fish cluster	Proportion of total landing biomass	US$/kg dominant fish in cluster
Buagsong	"Sea cucumber, abalone"	14%	$3.82
Buagsong	"Eels"	78%	$1.80
Buagsong	"Rabbitfish"	7%	$1.96
Buagsong	"Shellfish"	1%	$2.33
Gulod	"Shrimp"	2%	$10
Gulod	"Rabbitfish"	44%	$1.07
Gulod	"Squid, catfish"	9%	$2.20
Gulod	"Crab"	20%	$2.49
Gulod	"Shellfish"	19%	$1
Gulod	"MISC"	6%	$1.22

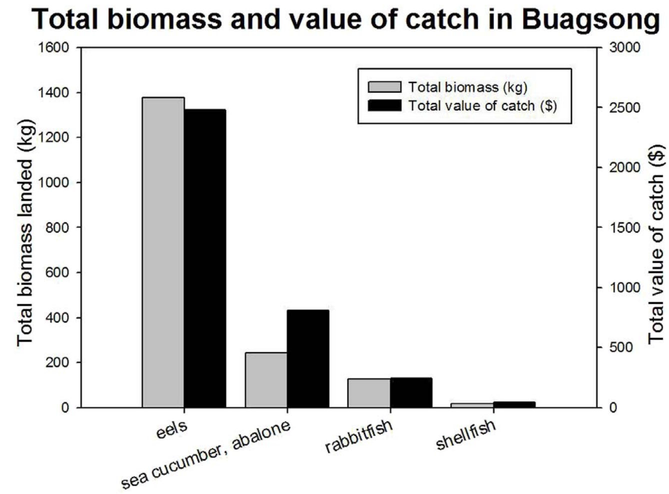

Fig. 3. Total biomass landed and value of catch for four fish clusters in Buagsong out of 608 landings, 28 observation days between June and September, 2013. Figure shows relative importance of seagrass catch in the seagrass fishery. Refer to Table 2 for membership of fish cluster.

higher in Gulod than Buagsong. Although prices for individual catch, with the exception of Penaeidae in Gulod, were higher in Buagsong, Gulod had higher total daily earnings (Tables 2 and 4, Appendix, Table 7). Common catch between Buagsong and Gulod were Siganidae and shellfish (Table 4, Appendix Table 8).

Seagrass catch was more diverse in Gulod versus Buagsong. We observed 11 Families of commonly caught fin-fish and invertebrates in Buagsong, which we grouped into four clusters (Tables 2 and 4). The main seagrass catch landed in Buagsong was Muraenidae (eel cluster), which made up 78% of the biomass from observed landings (Table 4, Fig. 3, Appendix Tables 5, 6, 8). We observed 20 Families of commonly caught fin-fish and invertebrates in Gulod, which we grouped six clusters. The main catch was Siganidae, Leiognathidae, Lethrinidae, and Gobiidae (rabbitfish cluster), which made up 49% of the biomass of observed landings (Tables 2 and 4, Fig. 4, Appendix Tables 5, 6, 8).

Catch from gleaning made up 15% of the total landings in Buagsong, and were mainly composed Holothuridae, Haliotidae and shellfish, while gleaning made up 22% of the total landings in Gulod, and composed of Paenidae and shellfish (Table 4, Appendix Table 8).

The reported daily catch per hour, defined by kilos caught per

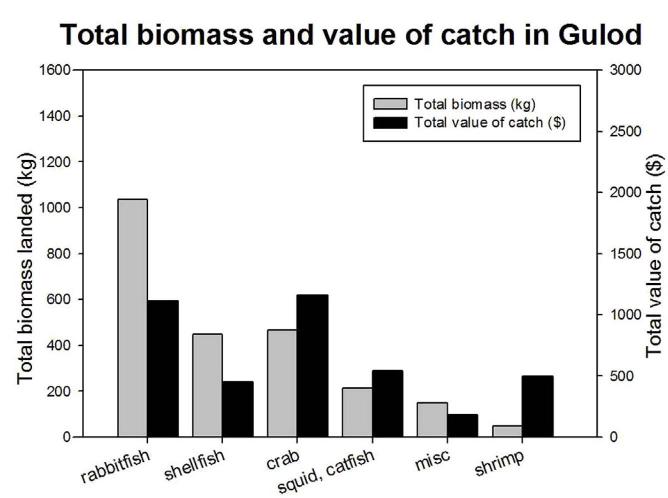

Fig. 4. Total biomass landed and value of catch for six fish clusters in Gulod out of 454 landings, 24 observation days between June and September, 2013. Figure shows relative importance of catch in the seagrass fishery. Refer to Table 2 for membership of fish cluster.

number of hours spent fishing for an individual fisher, was similar (Table 2, Appendix, Table 7), and ranged from 0 to 3 kg/hour fished in Buagsong and 0–5.23 kg/hour fished in Gulod (Table 2). There were no differences in the total number of hours for each fishing trip in Buagsong and Gulod (Appendix, Table 7).

Self-reported data from fisher surveys conflicted with data collected from fisher landing surveys because the reported daily total catch per fisher in kg from the fisher surveys in Gulod was not different from Buagsong, but the actual landing survey data showed less biomass landed in Buagsong versus Gulod (Appendix, Table 7).

While we observed the same number of fishers a day at the landing sites, between 20 and 23 fishers (Table 3), Buagsong fishers reported more trips per week because many fishers regularly took two fishing trips a day: one to catch bait and set the basket traps for juvenile morays, and the second to collect the traps. In Gulod, most fishers, with the exception of 7 crab trapping fishers, took one trip a day.

Proportion of gear types used were different. The primary gear type was eel trapping in Buagsong, and gillnet fishing in Gulod (Table 3, Appendix Table 6). The most popular secondary gear type was gleaning, when we combined daytime ("sikad") and nighttime ("ilaw") gleaners. Day and nighttime gleaners in Gulod captured fin-fish in the Gobiidae family (Appendix Table 6) using a cylindrical basket trap, which was placed directly on top of the fish to prevent escape. 82% of fishers surveyed in Buagsong also engaged in gleaning activities, 49% gleaned during the day, while 56% gleaned at night. In Gulod, 33% of fishers also gleaned, with 13% gleaned during the day, while 20% gleaned at night. Individual fishers in Buagsong utilized more diversified fishing methods, with up to four different gear types per fisher, compared to Gulod fishers, who used a maximum of two gear types (Table 3; Appendix, Table 7).

3.2. Sensitivity

3.2.1. Natural capital indicators: fisher landing surveys & fisher surveys

The take-home income in Gulod ($8.84) was greater than in Buagsong ($5.25). For comparison, the daily minimum wage in the Phillipines is $6 - $10. The daily overhead costs, however, were significantly greater in Buagsong (Table 2; Appendix Table 7) (Department of Labor and Employment, 2018).

The highest valued clusters in Gulod were Siganidae and Portunidae, while in Buagsong, they were Muraenidae, Holothuroidea and Haliotidae (Figs. 3 and 4). Catch that comprised the greatest landing biomass did not have the highest market value (Figs. 3 and 4). Muraenidae dominated the Buagsong catch biomass at 78% of total catch, with a value per kilogram of US$1.80 and Siganids dominated the Gulod catch biomass at 44% of the total catch, with a value per kilogram of US$2 (Appendix Table 6).

The highest market value items were captured by night gleaners ("ilaw"). In Gulod, Penaeidae comprised only 2% of the total catch biomass, but had a value per kilogram of US$10. In Buagsong, Holothuroidea and Haliotidae comprised 11.2% and 2.98% of the total catch biomass but had a value per kilogram of US$3.33 and US$8 (Table 4, Appendix Tables 6, 8). Gleaned invertebrates made up 15% of total landings in Buagsong and 22% in Gulod (Table 2) and were composed of the Holothuroidea and Haliotidae cluster in Buagsong and the shellfish and Penaeidae clusters in Gulod (Figs. 3 and 4).

Catch data did not align with underwater surveys, even though both data were both collected during the Habagat season. The most abundant Family from underwater surveys in Buagsong were Siganidae (41% of observations) but Siganids were not a dominant catch in Buagsong, and Holothuroids were not observed in abundance in the underwater surveys but were commonly caught. The most abundant Family from underwater surveys in Gulod were Atherinidae (38% of observations), but they did not make up a significant proportion of total biomass caught. Holothuroids in Gulod were a target catch but were minor (2%) observations in the underwater surveys (Appendix Tables 5, 6).

Table 5
Comparing (1) the quality of life indicator from household surveys in Buagsong (n = 72) and Gulod (n = 90), and (2) the importance of gleaning vs fishing for home consumption and income from fisher interviews in Buagsong (n = 80) and Gulod (n = 80), and household surveys. Importance scores were rated from a scale of 1–5, with 1 being Not important and 5 being Very important. Mdn = median values. U statistic from the Mann-Whitney test. p = significance values.

Rank	Buagsong (Mdn)	Gulod (Mdn)	U	p
Quality of life indicator	3	4	1548	0.000
Fisher surveys				
Importance of *gleaning* for subsistence	5	5	1910.5	0.029
Importance of *fishing* for subsistence	5	5	1635.5	0.576
Importance of *gleaning* for income	5	4	1958	0.004
Importance of *fishing* for income	5	5	1673.5	0.842
Household surveys				
Importance of *fishing/gleaning* for subsistence	5	5	2676	0.259
Importance of *fishing/gleaning* for income	1	4	127.4	0.000

From fisher surveys, Gulod fishers kept a greater proportion of catch for home consumption than Buagsong fishers (12% of biomass in Buagsong, 46% in Gulod). Of the fishers that kept their catch, Buagsong fishers reported keeping an average of 0.68 kg (0.25 kg–1 kg), while Gulod fishers reported keeping an average of 1 kg (0.1 kg–3.5 kg) (Table 2).

3.2.2. Socio-economic indicators: household surveys

A Mann-Whitney test indicated that the quality of life indicator was lower in Buagsong than Gulod (Tables 2 and 5). When we asked fishers what members of their household participated in gleaning versus fishing, seagrass fishing was done primarily by adult men, but gleaning in seagrass beds was more evenly distributed, with greater participation by women and children (Table 2, Fig. 5). Gleaning catch contributed 15% of the total biomass of catch in Buagsong (Holothuroidea and Haliotidae and shellfish) and 21% of the total biomass of catch in Gulod (Penaeidae and shellfish) (Table 4, Appendix Table 8).

3.3. Adaptive capacity

3.3.1. Natural capital indicators: fisher surveys

Most of fishers interviewed were full-time fishers, who fished everyday (88% Buagsong, 64% Gulod). In Buagsong, 73% of fishers owned 4 – 5-m length wooden outrigger motorized boats with 10-horsepower engines, compared to 58% of fishers in Gulod (Table 2). Motorized boats in Buagsong were owned by 2–4 people to cut the costs.

The primary occupation of fishers surveyed was boat-based fishing, 42% of fishers in Buagsong, 70% in Gulod. Gleaning was more prevalent in Buagsong and was the primary occupation of 52% of fishers

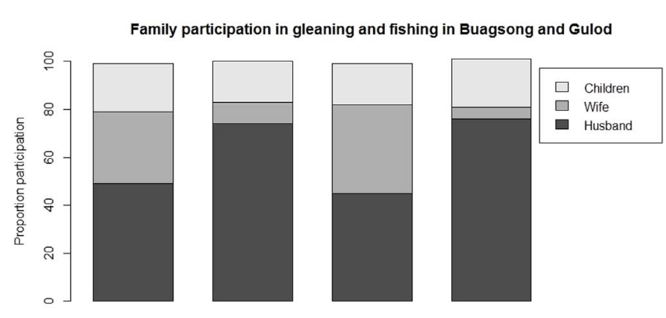

Fig. 5. Proportion of household participation in seagrass fishing (defined by using boats and nets) versus seagrass gleaning (walking in the intertidal) in Buagsong and Gulod by household members.

versus Gulod, 19%. No fishers in Buagsong stated farming as one of their occupations, while 15% of fishers in Gulod farmed (Table 2).

Gleaning augmented boat-based fishing for 66% of fishers in Buagsong, but only 22% in Gulod. Farming augmented boat-based fishing for 22% fishers in Gulod but none in Buagsong. Fish selling augmented boat-based fishing for 10% fishers in Buagsong, and 27% in Gulod. Miscellaneous sources of income, called "sideline" jobs augmented boat-based fishing for 24% fishers in Buagsong and 29% in Gulod. The "sideline" income was temporary, and respondents said they did not provide enough money to support a family. Buagsong fishers relied on gleaning, fishing, fish selling and "sideline" income, while Gulod fishers relied on gleaning, fishing, fish selling, farming, and "sideline" income (Table 2).

Gleaning was more important to Buagsong fishers. A Mann-Whitney test indicated that the importance of gleaning for home consumption was greater in Buagsong fishers than for Gulod, but the importance of fishing for home consumption was no different. The importance of gleaning for income was greater in Buagsong than for Gulod, while the importance of fishing for income was no different (Table 5).

From self-reported fisher surveys, most of the fishers' catch at both sites was sold in local markets, followed by municipal markets, and regional markets.

3.3.2. Socio-economic indicators: household surveys

Households differed in income sources and reliance on seagrass resources. Salaried income was more important to households in Buagsong (Table 2). Gleaning was more important to Buagsong households, who rated gleaning an importance of 5 out of 5 (Tables 2 and 5). Gulod households rated gleaning an importance of 4 out of 5 (Tables 2 and 5). While households in Buagsong and Gulod ranked that catch from fishing and gleaning were equally important for subsistence, they differed in household reliance on seagrass catch for income. A Mann-Whitney test indicated the importance of fishing and gleaning for household income was greater in Gulod (Table 5). The percentage of household income from seagrass fishing and gleaning in both communities averaged 20%. However, the percentage of household income from salaried employment was greater in Buagsong (Appendix Table 7).

3.3.3. Demographic indicators: fisher surveys and household surveys

Women made up the minority of fishers in Buagsong and Gulod (15%, 13%), but were the majority day time gleaners (61%, 71%), while men were the night time gleaners (Table 2). Women gleaners contributed to 9% of total catch from Buagsong and 16% in Gulod. There were no differences in fisher age in the two communities, with a pooled mean fisher age of 39 years ± 13 (Appendix, Table 7).

Households reported participation in gleaning and fishing activities by family members. In both communities, fathers had 75% participation in fishing, while less than half of fathers participated in gleaning. Mothers had less than 10% participation in fishing but had around 30% participation in gleaning. Children in Buagsong and Gulod had around 20% participation in both fishing and gleaning (Table 2).

4. Discussion

We assessed social vulnerability at different scales: overall community, seagrass fishers, and women. Natural capital indicators described the resource base, while socio-economic and demographic indicators described sensitivity and adaptive capacity (Fig. 1).

4.1. Natural capital indicators of vulnerability

Pre-existing natural conditions may influence a community's response to changes in the fishing resource, and the community's corresponding vulnerability (Cutter et al., 2008; Jepson and Colburn, 2013). The Buagsong community had a higher vulnerability than Gulod due to differences in catch diversity and habitat quality. Gulod had greater seagrass abundance and diversity, and higher biomass landed. Gulod's catch was more diversified than Buagsong's; 3 Families made up 80% of the landed biomass in Buagsong, compared to 12 families in Gulod. Buagsong's catch were mostly juvenile moray eels, while Gulod's catch was a mix of rabbitfish, emperor fish and parrotfish.

Underwater surveys did not coincide with landing surveys: the most common fish from the underwater surveys were not the most commonly caught species. This discrepancy could mean that rabbitfish avoided humans, and juvenile eels in Buagsong had nocturnal behavior and spent most of their time in holes, so both were not easily seen in the snorkel surveys. Another reason could be those fish were sparsely distributed due to overfishing. The local name for eels in Buagsong is "bakasi," and besides market demand for the eels, Buagsong fishers targeted the eel due to culture and identity; they were famous for harvesting the largest amounts of eel (Araw and Quiros, 2014). Furthermore, underwater surveys were not designed to capture the behavior of the eel during the day, a drawback of these field methods.

Catches from seagrass habitat included a broad range of Families: Siganidae, Penaeidae, Muraenidae, Trochidae, Turbinidae, Strombidae and Holothuridae, consistent with other tropical seagrass fisheries (Appendix Table 6) (Campos et al., 1994; Cullen-Unsworth et al., 2014; De La Torre-Castro et al., 2004; Fröcklin et al., 2014; Kleiber et al., 2014; Nordlund et al., 2011; Nordlund and Gullström, 2013; Unsworth and Cullen, 2010). Total fisheries landings in Buagsong and Gulod averaged less than 100 kg per day for a mixed invertebrate and fin-fish fishery and supported fewer fishers than what is reported from other studies. In Cape Bolinao, Philippines, the seagrass fishery historically yielded 4 kg per day per fisher (Campos et al., 1994). Seagrass catch for a mixed fin-fish and invertebrate fishery in Tanzania was approximately 3.4 kg per day per fisher (De La Torre-Castro and Rönnbäck, 2004). In Gulod and Buagsong, the mixed fin-fish and invertebrate fishery yielded approximately 0.7 kg per day per fisher. These estimations are based on the total number of fishers participating in the fishery, and not how many fishers are observed daily. The communities in Bolinao and Tanzania had fishing grounds which ranged in area from 24 km^2 (Campos et al., 1994) to 50 km^2 (De La Torre-Castro and Rönnbäck, 2004), while Gulod's fishing grounds are 20 km^2 and Buagsong's grounds are 30 km^2.

4.2. Sensitivity

Public infrastructure, housing, nutrition, poverty and income distribution are metrics of sensitivity (Beck et al., 2012). Different groups had different sensitivities to changes in the resource base, and these differences depended on the scale at which a group was investigated (Buckle et al., 2001).

4.2.1. Natural capital indicators of vulnerability

Gear dependence is an intrinsic attribute of a fishery, and sensitivity increases with gear dependence (Mamauag et al., 2013). The most sensitive gear type are fish pens ("baklad") (Mamauag et al., 2013). Fish pens make up 15% of fishers in Gulod. Changes in the seagrass bed quality has the potential to affect fishers who use fish pens because they may not have the option to relocate to other areas if their seagrass bed gets degraded.

4.2.2. Socio-economic indicators of vulnerability

Vulnerability increases when communities rely heavily on fisheries for food and income (Orencio and Fujii, 2013). Household dependence on seagrass resources for income was influenced by the availability of alternative incomes, and when fishers had access to alternative income, their adaptive capacity increased. Buagsong is a lower income class municipality and has a lower median quality of life indicator. But primary occupation of Buagsong households were from salaried jobs, while in Gulod, it was fishing. Coastal communities rely more greatly on seagrasses when there are no alternative land-based opportunities such as salaried employment or other capital investment (Cinner et al., 2009; Cullen-Unsworth et al., 2014; McClanahan et al., 2009). Buagsong is three times closer to a major metropolitan city and surrounded by an urbanized landscape with transportation networks and urban infrastructure, while Gulod is surrounded by an agricultural matrix, where fishing and farming are the main occupations. The main household income in Gulod was seagrass fishing, with households relied more heavily on natural resource jobs, making them more sensitive to changes in the resource base, increasing their social vulnerability.

We saw a different pattern looking at seagrass fishers. The take home income of a single fishing trip was greater in Gulod than in Buagsong, and the overhead costs of a trip were less in Gulod. Less income meant that Buagsong fishers were more sensitive to changes in the resource base. The seagrass fishery in Gulod contributed more to local food security than the seagrass fishery in Buagsong. In other locations, fishers kept a “fish home-pack” weighing between 0.5 and 2 kg of juvenile fish less than 10 cm in length (Campos et al., 1994; De La Torre-Castro and Rönnbäck, 2004). Half of Gulod fishers also kept some catch for home consumption, while a minority of Buagsong fishers kept catch. This difference could be due to market access, as well as local food preferences. Main sources of catch in Buagsong were juvenile morays and abalone, both regional delicacies that garnered higher municipal market prices, while in Gulod it was rabbitfish (by biomass) and shrimp (by earnings), preferred local food items.

4.2.3. Demographic indicators of social vulnerability

Vulnerability changed depending on the gender assessed. Men were less sensitive to changes in the resource base because of their more diversified gear types and catch, while women focused mainly on seagrass gleaning. With seagrass loss, women gleaners do not have access to other forms of fishing, such as fishing with boats to visit other habitats. Women in Buagsong and Gulod were day-time gleaners who focused their efforts on gastropods, bivalves, seaweeds and other lower priced items, however, some also captured sea cucumbers in low quantities. Our findings were similar to other seagrass fisheries: most day-time gleaners were women (Cullen-Unsworth et al., 2014; Kleiber et al., 2014; Nordlund et al., 2011; Nordlund and Gullström, 2013) (Table 2), women small-scale fishers participated in gleaning more than non-gleaning fishing activities (Kleiber et al., 2015), women gleaners preferred seagrass habitats and targeted invertebrate catch such as gastropods and bivalves, (Fröcklin et al., 2014; Kleiber et al., 2015). In Zanzibar, women gleaners were restricted to harvesting 3–5 days a week during the low tides because they did not know how to swim nor how to use other gear types; these women also had less access to boats and fishing gear, so they harvested close to their homes (Fröcklin et al., 2014).

We did not measure governance and institutional capacity, and when inadequate, these metrics could act as stressors to a community's vulnerability (Bennett et al., 2014). Fishers who use gillnets, crab or eel traps are male and are required to register their boats and gear. On the other hand, gleaning in the two communities is unregulated. Gleaning was more important to Buagsong because of the greater number of fishers who only gleaned and did not use other fishing gear. An unregulated gear type, like gleaning, with easy entry and no capital investment, could be a safety net for coastal communities that need supplementary income.

4.3. Adaptive capacity

Gender, food security, economic activities and livelihoods contribute to coastal communities community's adaptive capacity (Beck et al., 2012; Orencio and Fujii, 2013).

4.3.1. Socio-economic indicators of vulnerability

While the overall Buagsong community benefited from salaried jobs provided by nearby Cebu City, Buagsong fishers had less adaptive capacity because of less catch, less revenue and higher overhead costs associated with urban living. Daily biomass and earnings were greater in Gulod, while mean daily overhead costs of fishing in Buagsong was four times as much as in Gulod. Some fishers in both communities had a negative take-home from their fishing trip (Table 2).

When fishers had access to alternative incomes, their adaptive capacity increased. Gulod fishers had fish marketing, salaried jobs and farming to turn to if there were threats to the fishing resource and a loss of opportunities to fish. Buagsong fishers relied on a less diversified income portfolio; the main source of alternative income for Buagsong fishers did not provide enough money to support their families. Fishers in Buagsong had access to irregular, temporary “sideline” jobs. Furthermore, lack of education meant that Buagsong fishers were unable to diversify their work outside of fishing and gleaning (Araw and Quiros, 2014). While the Buagsong community was less socially vulnerable due to the availability of salaried incomes, Buagsong seagrass fishers were more socially vulnerable due to their lack of diversification of catch and income sources. Fisher dependence on only one livelihood makes them vulnerable to uncertainty and risks from the lack of income or savings during the off-season (Khattabi A, 2011; Lokuge G, 2011). One solution is diversification through a mixed livelihood portfolio: Sri-Lankan fishers engage in non-fisheries-related activities like agriculture, and Moroccan fishers diversify through agriculture and ecotourism (Khattabi A, 2011; Lokuge G, 2011).

The condition of artisanal and subsistence fisheries is related to a range of external socioeconomic factors (Berkes et al., 2001; Cinner and McClanahan, 2006). Seagrass fisheries near a large city may be under greater threat to overfishing because of higher population densities and a more degraded nearshore habitat; Gulod seagrass beds had greater abundance and diversity than Buagsong beds. Due to its proximity to Cebu City, Buagsong is experiencing growing tourism development. Human population growth is one of the main threats to seagrass fisheries resulting in overexploitation of invertebrates, flux of anthropogenic sewage, siltation from agriculture and forestry runoff, and coastal development (Grech et al., 2012). Tourism development may result in increased transient coastal populations, intensified fishing, sewage, and construction (Nordlund et al., 2011). Anthropogenic threats may affect seagrass and adjacent habitats, decreasing Buagsong fishers' adaptive capacity by impairing their ability to switch to alternative fishing grounds.

While remoteness and the lack of services are direct contributors to vulnerability (Buckle et al., 2001), we saw the opposite. Differences in catch were due to differential access to markets. Gulod had a greater proportion of its catch sold in local markets and less in municipal markets, so seagrass catch directly contributed to local food security. Buagsong was closer to a city and had a greater proportion of its catch sold in municipal markets. Most of the catch in Buagsong garnered higher prices per kilo than in Gulod, with the exception of shrimp. The high biomass of eels caught reflected a market preference in for Cebu City for this delicacy (65% of Buagsong's catch biomass was juvenile eels). Urban demand for juvenile morays may lead to overfishing, potentially reducing Buagsong fishers' adaptive capacity. These findings are similar to other studies that found that the presence or absence of human settlements and distance to fish markets strongly explained coral reef fishery condition, and fished biomass increased exponentially the closer the reef was to a market (Cinner et al., 2013).

4.3.2. Demographic indicators of social vulnerability

Women in Buagsong and Gulod were key players in reducing their household's vulnerability by participating in part-time seagrass gleaning. Part-time female gleaners reduced a community's social vulnerability and increased a community's adaptive capacity by engaging in this supportive fishing activity. Similar to other studies (Fröcklin et al., 2014; Kleiber et al., 2015, 2014), female gleaners in Gulod said they were gleaning for recreation and supplementary food gathering in their free time, and did not consider themselves full time fishers, and female gleaners in Buagsong said they caught items for home consumption and extra income. Other studies have found that part-time fishers were responsible for between a quarter to a third of the total catch biomass in other locations (Kleiber et al., 2014; Nordlund and Gullström, 2013) and women fishers (full-time and part-time) made up almost half of all fishers in fishing communities in Bohol, Philippines (Kleiber et al., 2014). Other studies found that gleaned invertebrates provided greater value of catch relative to their biomass, and protein and essential micro and macronutrients to household diets (Cullen-Unsworth et al., 2014; Fröcklin et al., 2014; Kleiber et al., 2015; N Kawarazuka, 2011; Nordlund et al., 2011; Nordlund and Gullström, 2013). With seagrass loss and the disappearance of gleaned invertebrates, a community's food security may be compromised.

Women's participation in gleaning and other fishing-related activities increased a community's adaptive capacity by increasing the potential workforce. In Gulod, we observed groups of women related through family or marriage, processing fish together, women and children drying juvenile (< 10 cm) rabbitfish for home consumption and selling at higher prices in the market, and fishermen's wives going to market with their husband's catch or selling house-to-house. The significant risk-reduction role for women in fishing households is an extension of their domestic role, because during times of crisis women initiate income diversification activities (Frangoudes, 2011). Fish processing and post-processing activities like drying and cooking can increase the value of the fish product (Juntarashote K, 2011; Lowitt K, 2011), while marketing and repairing nets, which have greater participation by women and children, bring additional income (Frangoudes, 2011; Lokuge G, 2011). Women gleaners in Zanzibar were often involved in seaweed farming and sold food items to augment their income (Fröcklin et al., 2014).

Housing and economic and fisheries dependence variables are not the only parameters of social vulnerability. The Intergovernmental Panel on Climate Change notes that the lack of social networks and social support mechanisms affect vulnerability (IPCC, 2012). Future assessments should examine social networks such as family ties and examine local support and leadership or social cohesion within a community (Buckle et al., 2001; UNU-EHS, 2014).

4.3.3. Management implications

Seagrass systems in the tropical Indo-Pacific would benefit from being included in marine protected areas (MPAs) because they are threatened and have high ecological vulnerability from non-trawling fishing activities (Grech et al., 2012; Unsworth and Cullen, 2010). While some seagrass habitats are included due to their proximity to coral reefs, there are not many Marine Protected Areas (MPAs) dedicated to seagrass habitat in the Philippines (Fortes, 2012). Dedicating seagrass MPAs should consider social vulnerabilities of communities that rely on those seagrass resources, and how fishers and communities' relationship with the resource could change.

Gleaning in seagrass beds targets invertebrates, but fisheries management mostly focuses on fish species (Armada et al., 2009; Fröcklin et al., 2014). Collecting data on the diverse participants and gear types engaged in seagrass fisheries will give management the proper context to match the scale at which the resources are being used (Kleiber et al., 2014) because siting of MPAs for fish species may not have the best consequences for all catch of interest (Kleiber et al., 2015, 2014). When creating an MPA, it is important to consider the activities of non-boat-using fishers because in Tuvalu, fisheries managers failed to share the trochus reintroduction program with women gleaners, who collected the introduced animals, resulting in program failure (Seniloli and Taylor, 2002).

4.3.4. Summary

Our study shows that small-scale fishing in seagrass beds provides important primary and supplementary income, a diverse fin-fish and invertebrate catch, and opportunities for women to participate in the fishery. This paper provides further evidence of the prevalence of small scale seagrass fisheries, showing that fishers stay in the industry, making less than $10US a day, despite declines in catches compared to other fishing sites twenty years ago, because fishing still provides valuable ecosystem services and helps reduce a community's social vulnerability. Descriptive studies such as these are needed because they highlight the importance of seagrass resources to income and food security in coastal communities. For countries where reliable and systematic data on fisheries is lacking, this study addresses much needed data gaps for managing small-scale fisheries.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2018.02.003.

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