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Impact of a marine protected area to fishery profitability and income distribution. Some evidence from the Gulf of Thailand (Mu Ko Chumphon National Park versus Chumphon Province)

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Abstract

Methodological difficulties, particularly when multifleet-multispecies fisheries are active, explain *pro parte* a weak research effort on the socio-economic impact of fishery activities after the implementation of a marine protected area. Two components of the socio-economic impact have been prioritized: the fishing unit profitability and the fishery household income distribution by comparing a marine protected area (Mu Ko Chumpon National Park) and an unprotected area (Chumphon Province) in Thailand. One can distinguish three phases: a bibliographical analysis, the carrying out of fishers village monographs and of a sample-based survey of fishery households. The sampling unit was the fishery household forming one or several fishing units defined by a *métier* (an association of a fleet, a main fishing gear, target species): 126 households forming 225 fishing units have been surveyed.

The positive impact of the MPA on fishery profitability is shown by a principal component analysis which indicates that there is a lower proportion of fishing units harvesting inside or in adjacent areas of the MPA (insiders who are benefitting from implicit access rights) which face negative profit than those fishing remote from the MPA but in Chumphon Province (outsiders). This positive impact is confirmed by the performance of Chi-square tests: the insiders have relatively higher profit per fishing day than outsiders and Chi-square tests show a greater homogeneity of profits per fishing day and a lower variability for the insiders.

A steady social impact from the MPA on fishery income distribution is revealed by the measure of concentration using an Herfindhal index and Lorenz curves which show the more egalitarian structure of insiders regarding the operating profit and the income per fishery household.

Keywords

Marine protected areas, socio-economic impact, fishing unit profitability, fishery household income distribution, Gulf of Thailand, Chumphon Province

1. INTRODUCTION

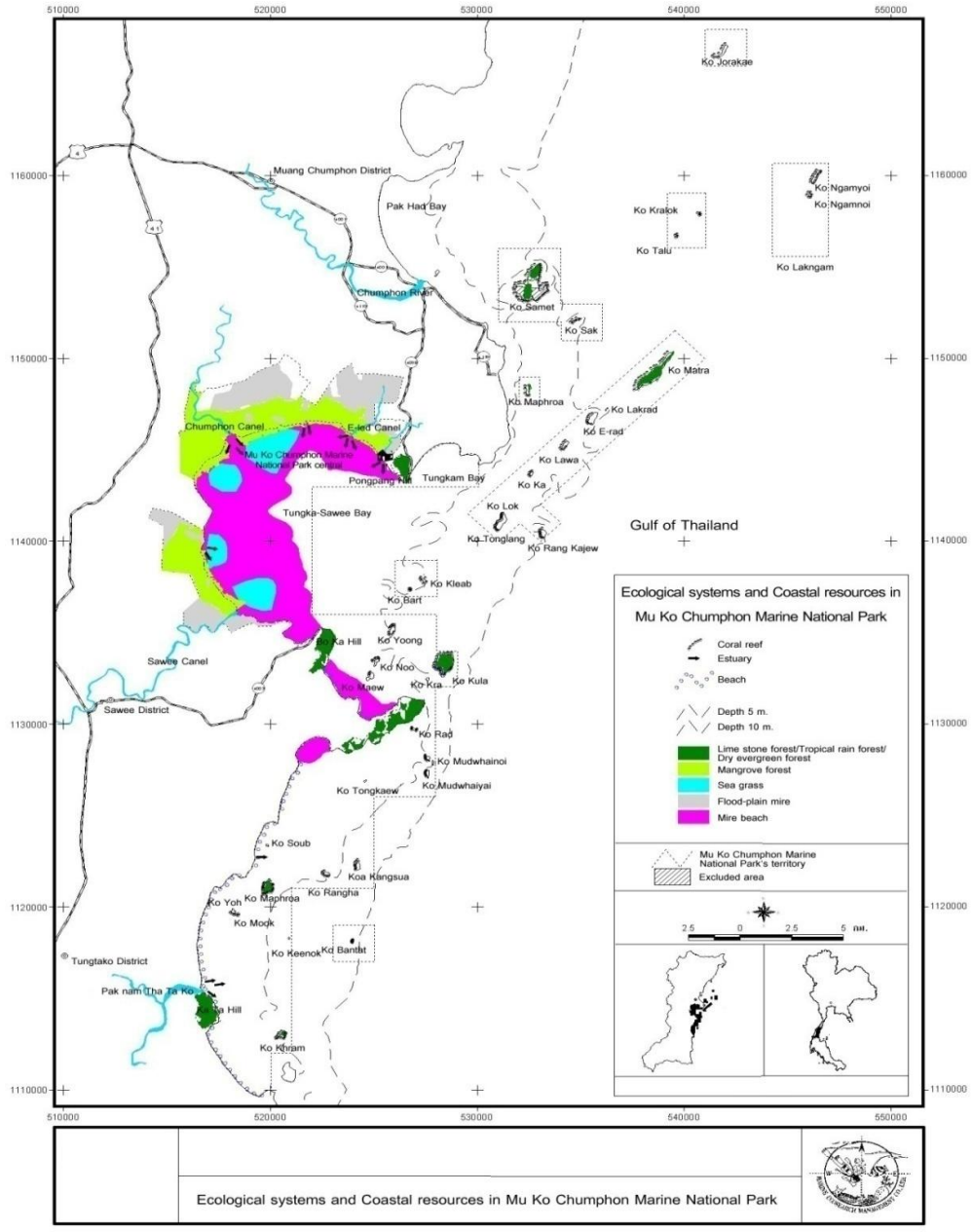
The general objective of this paper is a methodological proposal for the assessment of some socioeconomic impacts of a marine protected area on fishing activities. Methodological difficulties, particularly when multi-fleet multispecies fisheries are active, explain *pro parte* a weak research effort on the socioeconomic impact of fishing activities after the implementation of a marine protected area. To assess this impact, we proposed to focus on two components of this impact: the fishing unit profitability and the fishery household income distribution, a comparison between a marine protected area versus an "unprotected zone"

The institutional context was a general agreement between IRD (*Institut de Recherche pour le Développement*) and Kasetsart University (Faculty of Economics) under the supervision of Pr Ruangrai Tokrishna. This programme (2007-2009) was funded by IRD, ECOST Project (European Commission) and Kasetsart University. This paper has also benefitted from results of AMPHORE Project managed by IRD.

The case study was the Chumphon Province (five hundred kilometers south west of Bangkok) and the Mu Ko Chumphon National Park (MKCNP) along the Gulf of Thailand (see maps 1 and 2). Some features about Chumphon Province 6010 square kilometers, 500000 inhabitants, a population density of 74 inhabitants per square kilometer, eight districts (Mueang Chumphon, Lang Suan, Thung Takao, Sawi, Pathio, Tha Sae, Lamae, Phato), 2880 fishery households and 9580 fishery household members (from DOF 2006 Census). Some features about Mu Ko Chumphon National Park (see maps 2 and 3): established in 1999 under the supervision of the Department of National Parks, 317 square kilometers of which 265 of marine area, 70 kilometers of coastline, six main ecological systems (coral reef, seagrass bed, mangrove forest, limestone forest and tropical rainforest, food-plain mire, mud beach), spread over a part of fourth Chumphon province districts (Mueang Chumphon, Lang Suan, Thung Takao, Sawi, Pathio, Tha Sae, Lamae, Phato), 500 fishery households and 1700 fishery household members from IRD/ Kasetsart 2007 census (inside the Park and in communes just adjacent to the Park), the existence of a zoning (in particular a strict nature reserve and a general use zone in which the fishing from the residents is tolerated).

Map 1. Protected Areas (in green) and Marine Protected Areas (in blue) located in South Thailand

Map 2. Ecological Systems and Coastal Resources in Mu Ko Chumphon National Park (MKCNP)



2. THE METHOD

2.1. A bibliographical analysis and the carrying out of fishers village monographs

A first phase was devoted to a bibliographical analysis and interviews with Chumphon Province Department of Fisheries (DOF) officers and Direction of National Parks (DNP) officers focused on the features of fisheries activities and on the legislative and regulatory framework.

A second phase was devoted to village monographs which pointed out fisheries activities (type of fishing units, seasonal activities, location of fishing grounds) and fishery household occupational structure, monetary costs and fishery profitability, fishery household income distribution by fishing unit and by extra fishing source: seven fishers village monographs in Mu Ko Chumphon National

Park (MKCNP) or adjacent to the MKCNP and twelve fishers village in the rest of Chumphon Province.

2.2. A sample-based survey of fishery household

A third phase was devoted to a sample-based survey focused on fishery profitability and income distribution : 126 fishery households forming 225 fishing units were surveyed

The sampling strategy
The sampling unit was the fishery household which forms one or several fishing units. The data source was a 2006 census from the Department of Fisheries of Chumphon Province. Two types of stratification were adopted: a geographical stratification with communes (tambon) inside or adjacent to the MPA ("in and around the MPA"), and remote communes from the MPA ("remote from the MPA"), a stratification by the main "*métier*" (an association of a fleet, a main fishing gear and target species) used in and around the MPA (otter board trawler, anchovy purse seiner, anchovy falling netter, squid falling netter). The sampling rate was 15%: 126 fishery household forming 225 fishing units were drawn.

Table 1: Breakdown of the sample of Chumphon Province fishery household survey

Métier	**In and around the MPA ("insiders")**		**Remote from the MPA ("outsiders")**		**Total**	
	Census	*Sample*	*Census*	*Sample*	*Census*	*Sample*
Trawler/Otter board trawl/Trashfish	139	22	48	7	**187**	**29**
Seiner/Anchovy purse seine/ Anchovy	12	2	11	1	**23**	**3**
Netter/Anchovy falling net/ Anchovy	60	9	71	11	**131**	**20**
Netter/Squid falling net/Squid	283	42	209	32	**492**	**74**
TOTAL	**494**	**75**	**339**	**51**	**833**	**126**

The survey method
The drawing of the sample was as follows: for each stratum one must have a list of fishery household, for each list one applies a systematic random procedure: the first fishery household was drawn at random, then one fishery household was drawn every five fishery household. Every fishery household has been surveyed twice a year relating to the year 2007

The carrying out of a sample-based survey
A preliminary inquiry was carried out in February and March 2007: interviews with fishermen leaders at the level of each commune (*tambon*) to draw up the sample, to explain about the content of the survey with fishery households. Then, 126 fishery households covering 225 fishing units were surveyed: a first inquiry on July-August 2007 and a second inquiry on February-March 2008.

2.3.The data processing

The characterization of the categories of the variable « MPA » by quantitative variables
One can give a general description of the two categories ("inside or around the MPA" or "remote from the MPA") of the MPA variable with the most influential quantitative variables. The quantitative (or continuous) variables have been ranked by decreasing order of Test-values

(significant at the 5% level) for both positive and negative statistics (respectively greater and lower than average values).

A principal component analysis and a clustering with a characterization of the categories « in and around the MPA » versus « remote from the MPA »
A multivariate analysis was carried out on the basis of ten following continuous and nominal variables: average landing price for species 1, average landing price for species 2, average landing price for species 3, profit per fishing day, profit rate, wage rate, catch per fishing day, catch per fishing hour, share of wages in variable costs, profit over crew wages. It optimally gave (Ward criterion) five clusters that present several determining features.

A performance of Chi-square tests to study the relationship between profit per fishing day (PPFD) variable and the MPA variable
Two Chi-square tests have been performed to study for the relationship between a "profit per fishing day" (PPFD) variable divided into two categories (positive and negative PPFD).

The measurement of the concentration of income or operating profit and the drawing of Lorenz curves
A single a single indicator derived from Herfindhal index was selected. It was defined as the sum of the squares of the market shares compared to the sum of incomes or operating profits of all households. The indicator derived from Herfindhal index had two advantages : make possible the comparison of the levels of concentration between samples with different size and mark the indicator between 0 and 1. For an illustration of the concentration of income and operating profit per fishery household, two Lorenz curves have been drawn.

3. MAIN RESULTS

3.1. Main results from the fishers village monographs

A fishery household is formed by one or several fishing units defined by a *métier* which associated a fleet, a main fishing gear and target species

One can point out the most representative *métiers* in and just around the selected marine protected area: the squid falling netters (netter/squid falling net/squid) with 283 households, the otter board trawler (trawler/otter board trawl/trashfish) with 139 households, the anchovy falling netter (netter/anchovy falling net/anchovy) with 60 households, the anchovy purse seine (seiner/anchovy purser seine/anchovy) with 12 households.

The monographs allow to lacalize, with the help of the Chumphon Department of Fisheries, the main fishing grounds for each commune included in the sample, specially for the communes in and just adjacent to the MPA. This identification confirmed, first, that fishery units from these communes fish in or in the vicinity of the MPA, at the opposite of fishery units from the rest of Chumphon Province, secondly, the tolerance regarding the small-scale fishery activities of the MPA residents within the borders or just around Mu Ko Chumphon National Park (MKCNP). It revealed the implicit acknowledgement of exclusive access rights for the benefit of residents.

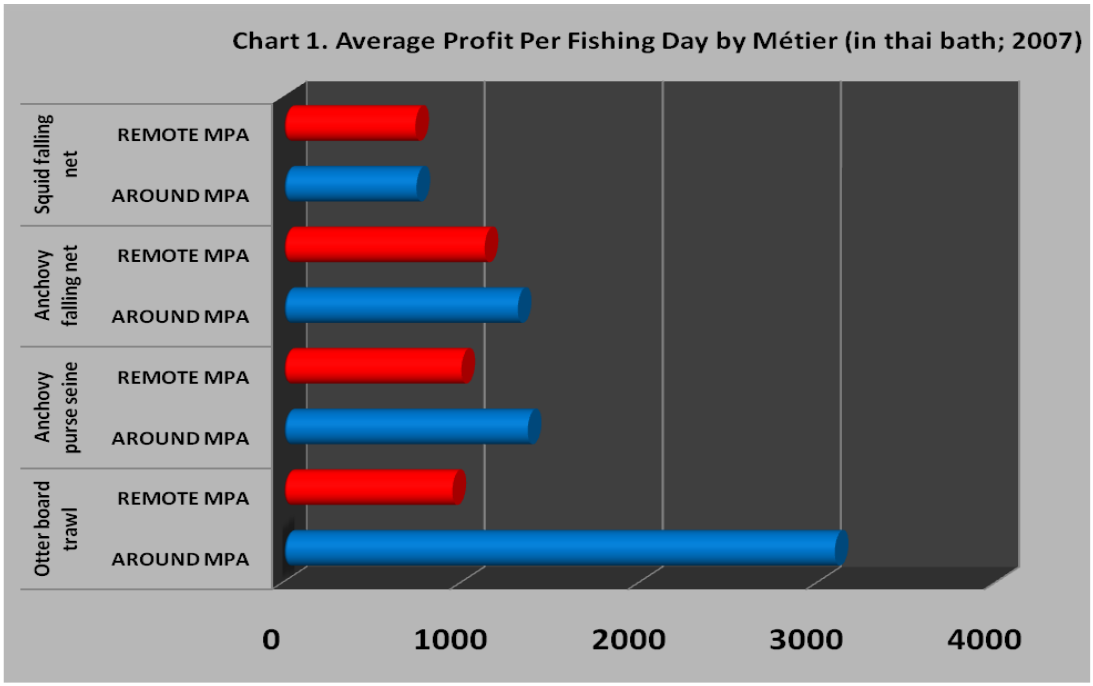
3.1. Main results from the sample-based survey

From the characterization of the categories of the variable "MPA" by quantitative variables
One can give a general description of the two categories ("inside or around the MPA or "remote from the MPA) of the variable "MPA" with the most influential quantitative variables in the following table (table 2). The quantitative (or continuous) variables have been ranked by decreasing order of Test-values (significant at the 5% level) for both positive and negative statistics (respectively greater and lower than average values).

Table 2 : Characterization of the categories of the variable "MPA" by quantitative variables

	Inside and around MPA		Outside MPA		t-Test value	Probability
Sample size	n= 57		n=41			
Variables	Mean	SD	Mean	SD		
Boat size	14,161	3,478	10,366	3,553	4,66	0,0000
Taxes	1560,53	1221,87	689,634	689,051	3,80	0,0001
Horse power	190,842	90,267	137,317	94,227	2,73	0,0037
PROFIT	277511	195106	186902	96686,6	2,64	0,0048
value for species 4	41165,1	88270,9	3586,83	13065,5	2,61	0,0053
Share of wages in VC	0,251	0,102	0,192	0,125	2,48	0,0074
FISHERY INCOME	830071	585998	543934	510952	2,44	0,0083
fishing hours	2055,44	1554,31	1381,83	1081,81	2,32	0,0111
Opportunity cost of labour	38231,6	15333,2	30948,3	15399,4	2,25	0,0132
Depreciation cost	32849,3	23497,8	22238,7	22776,4	2,18	0,0159
value for species 3	61643,5	125737	14209,8	69181,4	2,14	0,0176
FIXED COSTS	66917,1	62362,4	41055,8	51974,2	2,12	0,0184
Number of crew	5,351	2,737	4,049	3,208	2,11	0,0187
TOTAL COSTS	552559	444887	357033	462491	2,06	0,0208
euro	12279,1	9886,38	7934,06	10277,6	2,06	0,0208
Oil	13402,9	18678,4	6930,37	7518,98	2,05	0,0213
Rehabilitation	34,421	46,254	18,491	22,257	2,00	0,0242
Fuel	233344	233936	134973	239365	1,99	0,0246
VARIABLE COSTS	485474	414062	315884	433977	1,92	0,0287
MANAGEMENT COSTS	167,784	230,352	92,457	111,285	1,90	0,0301
Handling cost	6180,7	5299,9	4426,83	2827,48	1,89	0,0306
Administration	33,341	46,166	18,491	22,257	1,87	0,0321
Enforcement	50,011	69,249	27,737	33,385	1,87	0,0321
Research	50,011	69,249	27,737	33,385	1,87	0,0321
Fishing days	199,123	79,861	166,463	89,849	1,86	0,0329
Wage rate	22410,1	15242,9	15485,2	21535,4	1,83	0,0350
Average landing price species 6	27,83	26,098	38,65	6,671	-1,99	0,0247

In addition, the average profit per fishing day by *métier* (in thai bath) is higher in the case of the fishing units fishing in or just around the MPA (the insiders) than for the outsiders; mainly in the case of the otter board trawlers and anchovy purse seiners.



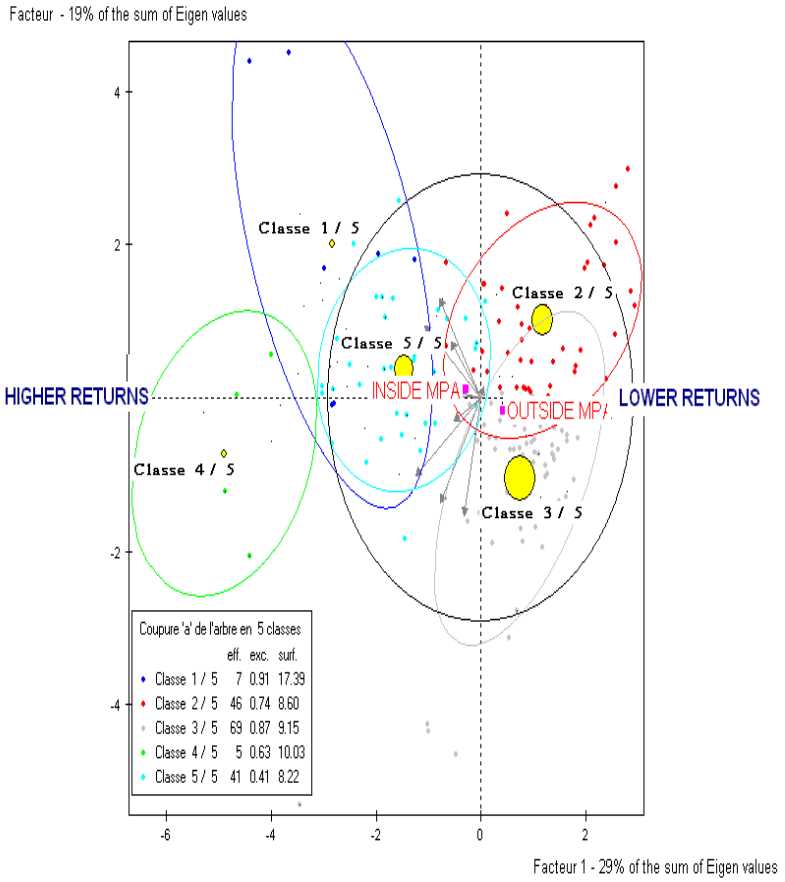
From the multivariate analysis and the clustering

The characterization of clusters by the quantitative variables is displayed in Weigel and al (2008).

We can point out two remarkable results: the proportion of insiders is higher in the high wage rate cluster (class 1; 7 obs.) and the proportion of outsiders is higher in the low profit rate cluster (class 2; 46 obs.).

But, at the overall level of the principal component analysis, the "in or around the MPA" variable is not significant in the three other classes. This is confirmed by the position of the MPA categories (inside *versus* outside): although situated on the left-hand side of the horizontal axis where all the returns and profits variables are linked together (thus the units having the highest returns are rather on this left-hand side of the factorial map), the "inside or around the MPA" category remains close to the centre of the map, hence to the average values of the ten variables. The "remote from the MPA" category is located on the right-hand side of the map (where the individuals having lower returns are) but it is also quite close to the center of gravity (average values).

Chart 2. Principal component analysis on the basis of ten variables



Legend : the pixel spots represent the observations (fishing units), the empty squares the qualitative (nominal) variables (including the MPA variable), the grey arrows denote the active continuous variables (all linked negatively with the first component) and the yellow full circles the centers of gravity of each class (with the specified number of observations in the framed legend)

From the performance of Chi-square tests to study the relationship between profit per fishing day (PPFD) variable and the MPA variable (table 3)

A first test significant at the 5% level, shows that the low profit population is twice more important "remote from the MPA" than "in or around the MPA"; or in other words, at the 95% of significance we found a significant relationship between the profit per fishing day level and the MPA variable :

Table 3: Profit per fishing day in two categories "in or around the MPA" and "remote from the MPA"

	Negative PPFD			**Positive PPFD**			**TOTAL**		
	% row	*Size*	*%column*	*% row*	*Size*	*%column*	*% row*	*Size*	*%column*
IN or AROUND MPA	12,5%	16	41,0%	87,5%	112	60,2%	100,0%	128	56,9%
REMOTE FROM MPA	23,7%	23	59,0%	76,3%	74	39,8%	100,0%	97	43,1%
TOTAL	17,3%	39	100,0%	82,7%	186	100,0%	100,0%	225	100,0%

KHI2 = 4.09 / 1 DEGREES OF FREEDOM / PROBA (KHI2 > 4.09) = 0.043 / TEST-VALUE = 1.72

From table 3, higher profit fishing units are relatively more represented inside or around the MPA than remote from the MPA although the difference of proportions between the two categories (inside and outside) is not so straightforward. However, another interesting insight is given by splitting up the positive PPFD category into two categories: positive earnings less than 4000 thai bath and earnings of 4000 thai bath or more, The new test shows greater homogeneity of returns "in or around" than "remote from the MPA": four fishing units out of five make up the mid-profit category for the "in or around the MPA" population against only two thirds as far as the "remote from MPA" population is concerned (table 4). In other words, the MPAs are likely to result in fewer units facing negative profits and lower variability.

Table 4: Profit per fishing day in three categories "in or around the MPA" and "remote from the MPA"

	Negative PPFD			**Medium PPFD**			**High PPFD**			**TOTAL**		
	% row	*Size*	*%column*	*% row*	*Size*	*%column*	*% row*	*Size*	*%column*	*% row*	*Size*	*%column*
IN or AROUND MPA	12,5%	16	41,0%	81,3%	104	61,5%	6,3%	8	47,1%	100,0%	128	56,9%
REMOTE FROM MPA	23,7%	23	59,0%	67,0%	65	38,5%	9,3%	9	52,9%	100,0%	97	43,1%
TOTAL	17,3%	39	100,0%	75,1%	169	100,0%	7,6%	17	100,0%	100,0%	225	100,0%

KHI2 = 6.16 / 2 DEGREES OF FREEDOM PROBA (KHI2 > 6.16) = **0.046** / V.TEST = 1.69

From the measurement of the concentration of income or operating profit per fishery household and from the Lorenz curves

In calculating an indicator derived from Herfindhal index on incomes per fishery household (n = 78 IN et n = 51 OUT), we have got a value of 1,72% for the insiders versus 5,81% for the outsiders; it means a higher concentration for outsiders.

The non-egalitarian structure of outsiders is more evident in considering the operating profits; if we exclude negative operating profits, the value of the index is 3,45% for the insiders and 14,57% for the outsiders. It is confimed by the shape of two Lorenz curves, one relating to the concentration of income per fishery household, the second one relating to the concentration of operating profit per fishery household. The two Lorenz curves show that the concentration of incomes or operating profits is higher for the outsiders. A such concentration of outsiders refers to a more non-egalitarian distribution.

Chart 3. Lorenz curve of income per fishery household

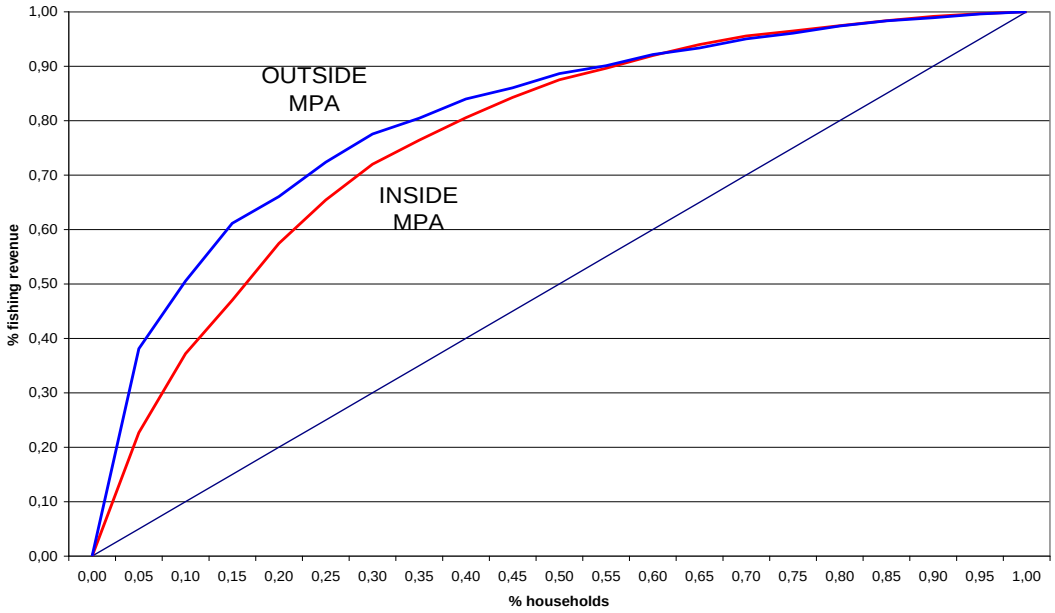
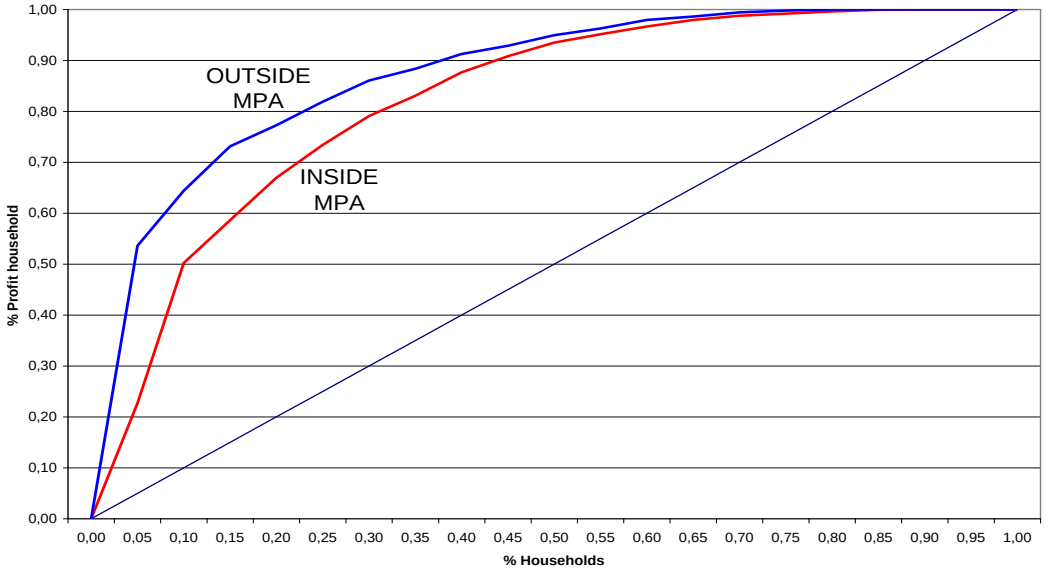


Chart 4. Lorenz curve of operating profit per fishery household



REFERENCES

Angulo-Valde, J.A. and Hatcher, B.G. 2009, A new typology of benefits derived from marine protected areas. *Marine Policy* (accepted 7 Dec 2009).

Bailey, M. Rotinsulu, C. Sumaila, U.R. 2008, The migrant anchovy fishery in Kabui Bay, Raja Ampat, Indonesia:Catch, profitability, and income distribution. *Marine Policy* 32 (2008) 483–488

Armstrong C.W.,2007, A note on the ecological–economic modelling of marine reserves in fisheries. *Ecological Economics* 62 (2007) 242-250

Béné, Ch. 2009, Are Fishers Poor or Vulnerable? Assessing Economic Vulnerability in Small-Scale Fishing Communities. *Journal of Development Studies*,. Vol. 45, No. 6, 911–933, July 2009

Cinner, J.E. McClanahan, T.R. Wamukota, A. 2010, Differences in livelihoods, socioeconomic characteristics, and knowledge about the sea between fishers and non-fishers living near and far from marine parks on the Kenyan coast *Marine Policy* 34 (2010) 22–28

Gravestock, P. Callum, M. R. Bailey, A. 2008. The income requirements of marine protected areas. *Ocean & Coastal Management* 51 (2008) 272-283

Hilborn, R. Stokes, K. Maguire, J-J. Smith, T. Botsford, L.W. Mangel, M. Orensanz, J. Parma, A. Rice, J. Bell J. Cochrane, K.L. Garcia, S. Hall, S.J. Kirkwood, G.P. Sainsbury, K. Stefansson, G. Walters, C. 2004, When can marine reserves improve fisheries management? *Ocean & Coastal Management* 47 (2004) 197–205

Lunn K.E. Dearden, Ph. 2006, Monitoring small-scale marine fisheries: An example from Thailand's Ko Chang archipelago. *Fisheries Research* 77 (2006) 60–71

Noël, J.-F. Weigel, J.Y. 2007, Marine protected areas: from conservation to sustainable development. *International Journal of Sustainable Development, 10*(3), 233-250.

Noël, J.-F. Weigel, J.Y. Morand, P. 2007, Defining criteria and indicators for the comparison of marine protected areas versus unprotected areas. *ECOST Paper 8.1*.

Ovetz, R., 2006, The bottom line: An investigation of the economic, cultural and social costs of industrial longline fishing in the Pacific and the benefits of sustainable use marine protected areas. *Marine Policy 30 (2006) 809–820*

Ruangrai, Tokrisna, 2000, Conflict in Fishery Resource Utilization: The Case of Light Luring Anchovy Fishery in Thailand . Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Bangkok,.Thailand.

Sumaila, U.R. Armstrong C.W., 2003, Distributional effects of Marine Protected Areas: A study of the North-East Atlantic cod fishery. *Working Paper Series in Economics and Management* No. 02/03, January 2003. University of Tromso.

Stobutzki, I.C. G.T. Silvestre, G.T.. Talib, A. Krongprom, A. Supongpan, M. Khemakorn, P. Armada, N. Garces, L.R.**,** 2006, *Fisheries Research* 78 (2006) 130–142

Thamasak, Yeemin. Makamas, Sutthacheep. Rattika, Pettongma, 2006, Coral reef restoration projects in Thailand *Ocean & Coastal Management* 49 (2006) 562–575

Tippawan, Sethapun, 2000, *Marine National Parks in Thailand*. Department of National Parks. Bangkok.

Tobey,, J. Torell, E., 2006, Coastal poverty and MPA management in mainland Tanzania and Zanzibar. *Ocean & Coastal Management* 49 (2006) 834–854

Weigel, J.Y., Thuntada Mawongwai (2009). Governance of marine protected areas in developing countries: an analysis framework. Evidence from Thailand. Communication invited by the French Agency of Marine Protected Areras at the *International Marine Conservation Congress 2009*. Washington (George Mason University, USA, 19-24 May 2009).

Weigel, J.Y. Mawongwai, T. Guillotreau, P. Noël, J.-F., Morand, P., 2008, Data processing of fisheries household sample survey to compare the societal cost of fishing activities in marine protected areas and in unprotected zones: results from Chumphon survey (Gulf of Thailand). *ECOST Paper 8.3*.

Weigel, J.Y. Féral, F. Cazalet, B. (Editeurs scientifiques.), 2007, *Les aires marines protégées d'Afrique de l'Ouest. Gouvernance et politiques publiques*. PUP. 238 p.

Weigel, J.Y. and J.F. Noël, 2007, Selected indicators and data collection program to compare the societal cost of fishing activities in marine protected areas and in unprotected zones. *ECOST Paper 8.2*.