A methodology to assess some socio-economic effects of marine protected areas

Jean-Yves Weigel

CRISP Economic Workshop
"**Investing in Coral Reefs: Is it worth it?"**
Noumea, New Caledonia
November 22–26, 2010

Invited paper
Funded by the French Pacific Fund (SPP)

A methodology to assess some socio-economic effects of marine protected areas

by Jean-Yves Weigel
(Economist, Research Director at IRD/UMR PRODIG; jean-yves.weigel@ird.fr)

Abstract

The assessment of socio-economic effects of marine protected areas on fishing activity points out some methodological difficulties. As a methodology we propose a selection of two components: the fishing unit profitability and the fishery household income distribution and a comparison between a marine protected area versus an "unprotected zone". The methodology has been applied on a case study: the Chumphon National Park versus the Chumphon Province (Gulf of Thailand).
Three phases have been implemented: a bibliographical analysis, the carrying out of village monographs, the carrying out of a sample-based survey. The sample-based survey results are presented as follows : the characterization of categories of the variable "marine protected area" by quantitative variables, a multivariate analysis, the performance of Chi-square tests on the relationship between a "profit per fishing day" variable divided into two categories ("in or around MPA" and "remote from the MPA", the measurement of the concentration of income or operating profit per fishery household and the Lorenz curves.

Key words

marine protected area, socio-economic impact, fishing unit profitability, fishery household income, methodological proposals, village monographs, sample-based survey, multivariate analysis, Chi-square tests, Lorenz curves

1. Methodological difficulties and proposals

The assessment of socio-economic impacts of a marine protected area on fishing activities points out some methodological difficulties, particularly when multifleet-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: a selection of two components of this impact (the fishing unit profitability and the fishery household income distribution) and a comparison between a marine protected area versus an "unprotected zone"

The institutional context was a research agreement between IRD (*Institut de Recherche pour le Développement*) and Kasetsart University (Faculty of Economics) under the supervision of Pr Ruangrai Tokrishna. This programme was funded by IRD, ECOST Project and Kasetsart University.
The case study was the Chumphon Province and the Mu Ko Chumphon National Park (MKCNP) along the Gulf of Thailand.

2. A case study : Chumphon National Park versus Chumphon Province (Gulf of Thailand)

2.1. Chumphon Province

- 6010 square kilometers, 446000 inhabitants, a population density of 74 inhabitants per square kilometer
- 8 districts : Mueang Chumphon, Lang Suan, Thung Takao, Sawi, Pathio, Tha Sae, Lamae, Phato
- 2880 fishery households and 9580 fishery household members

2.2. Mu Ko Chumphon National Park (MKCNP)

- 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
- four main ecological systems : coral reef, seagrass bed, mangrove forest, limestone forest and tropical rainforest, food-plain mire, mud beach
- MKCNP is spreading 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 (inside the Park and in communes just adjacent to the Park)
- a zoning : a strict nature reserve and a general use zone in which the fishing from the residents is tolerated

3. The method

3.1. Bibliographical analysis

A first phase 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.

3.2. Village monographs

A second phase devoted to field investigations which took the shape of village monographs and a sample-based survey

- The fishers village monographs were focused on fisheries activities (type of fishing units, seasonal activities, location of fishing grounds) and on fishery household occupational structure, monetary costs and fishery profitability, fishery household income distribution by fishing unit and by extra fishing source: *7 fishers village monographs in Mu Ko Chumphon National Park (MKCNP) or adjacent to the MKCNP and 12 fishers village in the rest of Chumphon Province*
-The sample-based survey was focused on fishery profitability and income distribution : 126 fishery households forming 225 fishing units were surveyed

3.3. A sample based survey

A third phase devoted to the processing of village monographs and to the sample-based survey

3.3.1. The sampling strategy

The sampling unit is the *fishery household* which forms one or several *fishing units*
The data source is a 2006 census from the Department of Fisheries of Chumphon Province (Gulf of Thailand).
Two types of stratification :
- a geographical stratification : the communes (*tambon*) inside or adjacent to the MPA, called "*in and around the MPA*", versus the remote communes from the MPA called "*remote from the MPA*"
- a stratification by the main "*métier*" 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 0: Breakdown of the sample of Chumphon Province fishery household survey

Métier	**In and around the MPA (MKCNP) (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**

3.3.2. The survey method and the carrying out of the sample survey

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 is drawn at random, then one fishery household is drawn every five fishery household.

The frequency of the survey: every fishery household has been surveyed twice a year relating to the year 2007

The carrying out of the sample-based survey :
- a preliminary inquiry (February-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
- 126 fishery households covering 225 fishing units have been surveyed: a first inquiry on July-August 2007 and a second inquiry on February-March 2008

3.3.3. The processing of the sample-based survey

- The development of an excel file to enter and store the data

- The characterisation of the categories of the variable « in and around the MPA » (insiders) versus « remote from the MPA » (outsiders) by a selection of quantitative variables. We have ranked the quantitative or continuous variables by decreasing order of Test-values significant at 5% for both positive and negative statistics (respectively greater and lower than average values)

- A principal component analysis and a clustering with a caracterisation of the categories « in and around the MPA » versus « remote from the MPA » by 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 (Fig.1).

- A performance of Chi-square tests to test the relationship between profit per fishing day (PPFD) variable and MPA variable ("in or around the MPA" versus "remote from the MPA"). Two Chi-square tests have been performed ; the "profit per fishing day" (PPFD) variable was divided into two categories (positive and negative PPFD).
- The measurement of the concentration of income or operating profit per fishery household by a single indicator derived from Herfindhal index 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 has two advantages : make possible the comparison of the levels of concentration between samples with different size and mark the indicator between 0 and 1.

- The drawing of Lorenz curves

4. Main results of village monographs

A fishery household is formed by one or several fishing units defined by a *métier* which associates a fleet, a fishing gear and target species.
The tolerance regarding the small-scale fishery activities of the MPA residents within the borders or just around Mu Ko Chumphon National Park (MKCNP).
The pointing out of 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 (natter/anchovy falling net/anchovy) with 60 households, the anchovy purse seine (seiner/anchovy purser seine/anchovy) with 12 households.
The identification of main fishing grounds for each commune included in the sample, specially for the communes in and just adjacent to the MPA. This identification confirmed 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. It means the implicit acknowledgement of exclusive access rights for the benefit of residents

5. Main results of the sample based survey

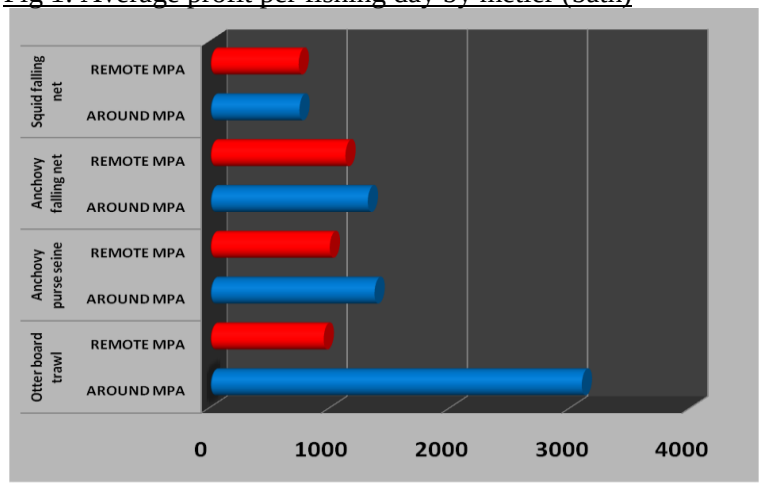
- from the characterization of the categories of the variable "MPA" by quantitative variables

Table 1.

IN THE MPA

Distinctive variables	Mean in the category	Overall mean	Standard deviation in the category	Overall standard deviation	Test-Value	Probability
HIGHER THAN AVERAGE						
Boat size	14,161	12,574	3,478	3,978	4,64	0,000
Taxes	1560,530	1196,170	1221,870	1118,730	3,78	0,000
Horse power	190,842	168,449	90,267	95,660	2,72	0,003
PROFIT	277511,000	239603,000	195106,000	167480,000	2,63	0,004
value for species 4	41165,100	25443,600	88270,900	70334,800	2,60	0,005
Share of wages in VC	0,251	0,226	0,102	0,116	2,47	0,007
FISHERY INCOME	830071,000	710361,000	585998,000	573477,000	2,42	0,008
fishing hours	2055,440	1773,620	1554,310	1416,050	2,31	0,010
cost of labour	38231,600	35184,500	15333,200	15775,500	2,24	0,012
Depreciation cost	32849,300	28410,200	23497,800	23781,900	2,17	0,015
value for species 3	61643,500	41798,800	125737,000	108376,000	2,13	0,017
FIXED COSTS	66917,100	56097,500	62362,400	59623,000	2,11	0,018
Number of crew	5,351	4,806	2,737	3,012	2,10	0,018
TOTAL COSTS	552559,000	470757,000	444887,000	462504,000	2,05	0,020
euro	12279,100	10461,300	9886,380	10277,900	2,05	0,020
Oil	13402,900	10695,000	18678,400	15387,300	2,04	0,020
Rehabilitation	34,421	27,757	46,254	38,902	1,99	0,023
Fuel	233344,000	192189,000	233936,000	241155,000	1,98	0,024
VARIABLE COSTS	485474,000	414524,000	414062,000	430710,000	1,91	0,028
MANAGEMENT COSTS	167,784	136,270	230,352	193,454	1,89	0,029
Handling cost	6180,700	5446,940	5299,900	4520,030	1,89	0,030
Administration	33,341	27,128	46,166	38,737	1,86	0,031
Enforcement	50,011	40,693	69,249	58,105	1,86	0,031
Research	50,011	40,693	69,249	58,105	1,86	0,031
Fishing days	199,123	185,459	79,861	85,712	1,85	0,032
Wage rate	22410,100	19512,900	15242,900	18461,700	1,82	0,034
LOWER THAN AVERAGE						
Average landing price for species 6	27,000	34,294	26,098	26,537	-1,98	0,024
Profit over crew wages	3,572	5,911	2,979	10,894	-2,49	0,006
Profit rate	0,355	0,392	0,128	0,155	-2,74	0,003

Fig 1: Average profit per fishing day by métier (bath)



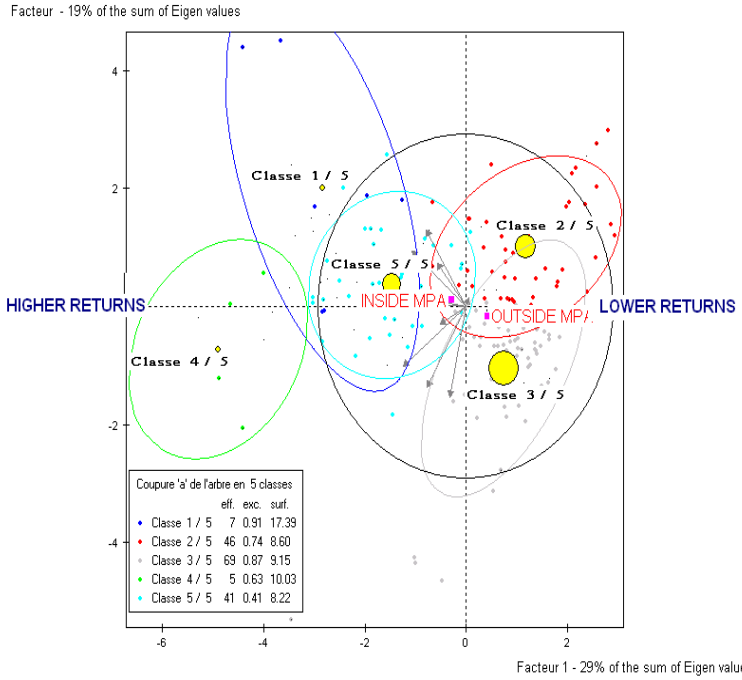
- from the multivariate analysis :

The results are not so evident. But we can point out that 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.). Or the proportion of outsiders facing negative profit rates is higher than the proportion of insiders.

But, at the overall level of the PCA, the "in or around MPA" variable is not significant in the three other classes. This is confirmed by the position of the MPA categories (inside *vs* 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 MPA" category remains close to the centre of the map, hence to the average values of the ten variables. The OUTSIDE 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 centre of gravity (average values).

Fig2: Multivariate 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 centres of gravity of each class (with the specified number of observations in the framed legend)



- from the performance of Chi-square tests on the relationship between a "profit per fishing day" (PPFD) variable divided into two categories (positive and negative PPFD).

- A first test shows that the outsiders having a low profit are twice more important than the insiders : at the 95% of significance we found a significant relationship between the profit per fishing day level and the MPA variable ("in or around the MPA" or "remote from the MPA")

Table 2: 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 THE MPA	12,5%	16	41,0%	87,5%	112	60,2%	100,0%	128	56,9%
REMOTE FROM THE 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

- A second test shows the greater homogeneity and the lower variability of profits for insiders: four fishing units out of five made up the mid-profit category for the insiders against only two thirds as far as the outsiders are concerned.

Table 3: 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 THE MPA	12,5%	16	41,0%	81,3%	104	61,5%	6,3%	8	47,1%	100,0%	128	56,9%
REMOTE FROM THE 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

The two Lorenz curves show that the concentration of incomes or operating profits is higher for the outsiders. A such concentration refers to a more non-egalitarian distribution.
In calculating the 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.

Fig 3. Lorenz curve of income per fishery household

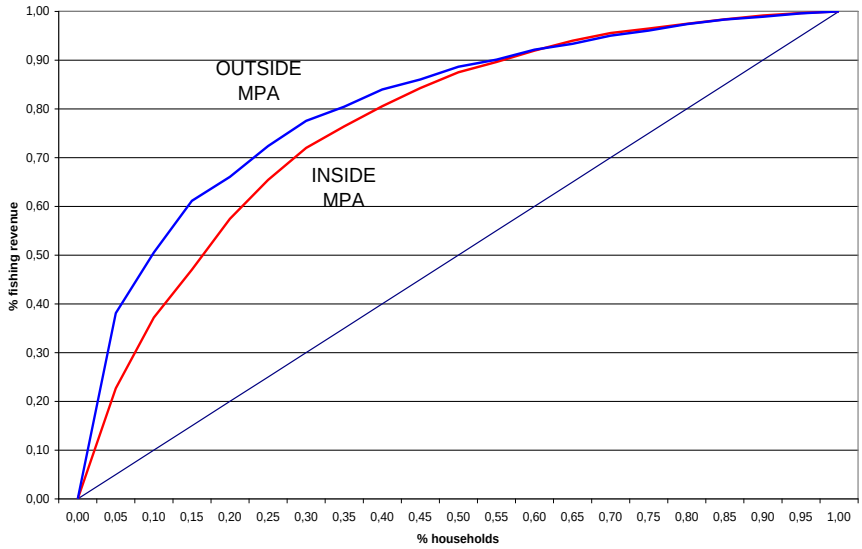
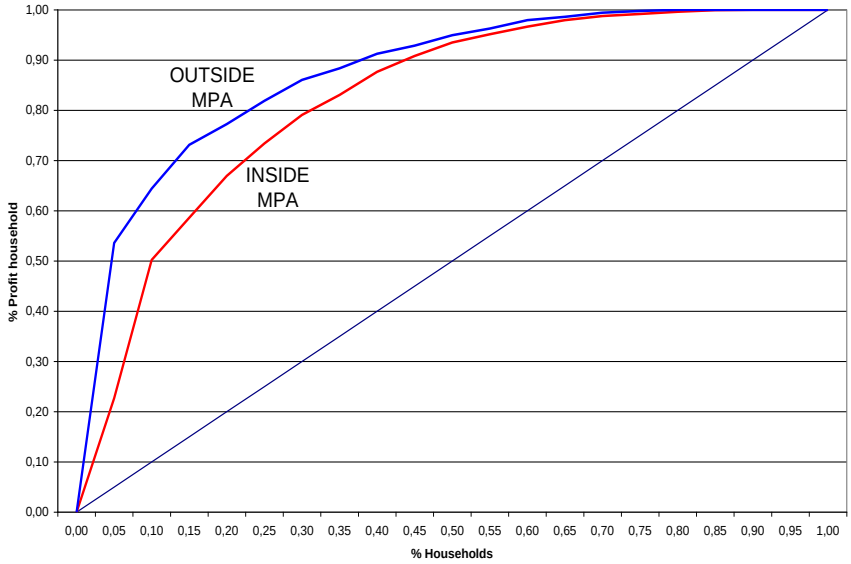


Fig 4. Lorenz curve of operating profit per fishery household



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., Guillotreau P., Mawongwai T., Noël J-F. (2010). Impact of marine protected areas to fishery profitability and income distribution. Evidence from Thailand (Chumphon Province). Communication à la Conférence IIFET 2010 (International Institute for Fisheries Economics and Trade), Montpellier, 13-16 juillet 2010) 10 p.

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*.