

A REVIEW OF QUANTIFIED RELATIONSHIPS BETWEEN MANGROVES AND COASTAL RESOURCES.

Eric Baran
University Lyon-1, France

ABSTRACT

This paper focuses on relationships between mangroves and coastal resources (fish and shrimps). A review of the literature highlights the lack of quantified relationships in this field. This leads to a definition of priorities for further scientific research.

INTRODUCTION

As mangroves are the dominant coastal biotope in Southeast Asia (Spalding *et al.*, 1996) and thus a major area of concern for coastal managers (Chua & Pauly, 1989; SEAFDEC, 1997), it is important to provide these managers with updated information regarding mangrove ecology. In this context the present paper summarises current knowledge about quantified relationships between mangroves and coastal resources.

In fact mangroves are frequently claimed

to be important for fishes and the ecological background of these relationships is well documented (Robertson & Blaber, 1992; Twilley *et al.*, 1996; Blaber 1997), but rigorously quantified relationships are surprisingly few, as shown Table 1.

RELATIONSHIPS BETWEEN MANGROVES AND FISH RESOURCES

To our knowledge, only Yañez-Arancibia *et al.* (1985) have shown and detailed a high positive correlation between commercial fish catches and

Table 1. Quantified relationships between mangroves and coastal resources

Reference	Formula	X	Y	r ²	n
Yañez-Arancibia <i>et al.</i> (1985)	$\text{Ln } Y = 0.496 \text{ Ln } X + 6.070$	Coastal marshes in km ²	Fish capture (tons)	0.48	10
Turner (1977)	$Y = 1.96 X - 4.39$	% of saline vegetation in an hydrological unit	Percentage of brown shrimps	0.92	7
	<i>No equation given</i>	Hectares of vegetated estuary	Annual shrimp yield	0.69	5; 8
Martosubroto & Naamin (1977)	$Y = 0.1128 X + 5.473$	Mangrove area (x10 000 ha)	Shrimp production (x1000 tons)	0.79	
Paw & Chua (1989)	$Y = 0.8648 X + 0.0991$	Log10 of mangrove area	Log10 of penaeid shrimp catch (tons)	0.66	17
Staples <i>et al.</i> (1985)	$Y = 1.074 X + 218.3$	Mangrove shoreline (Km)	Banana prawn catch (tons)	0.58	6
Pauly & Ingles (1986)	$\text{Log}_{10} \text{MSY} = 0.4875 \text{ log}_{10} \text{AM} - 0.0212L + 2.41$	MSY = Maximum Sustainable Yield of penaeids AM = area of mangroves L = degrees of latitude			

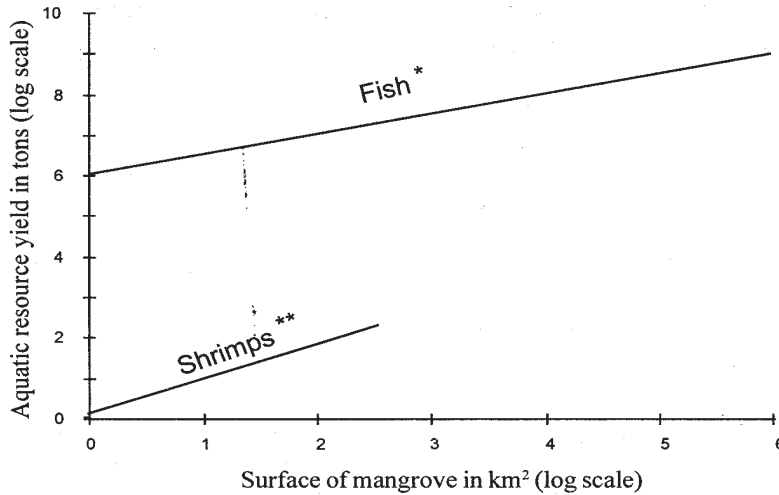


Figure 1. Simulated log-log relationships between surface of mangrove (Ln X) and resource harvested (Ln Y). * Yañez-Arancibia *et al.* (1985) ** Paw & Chua (1989)

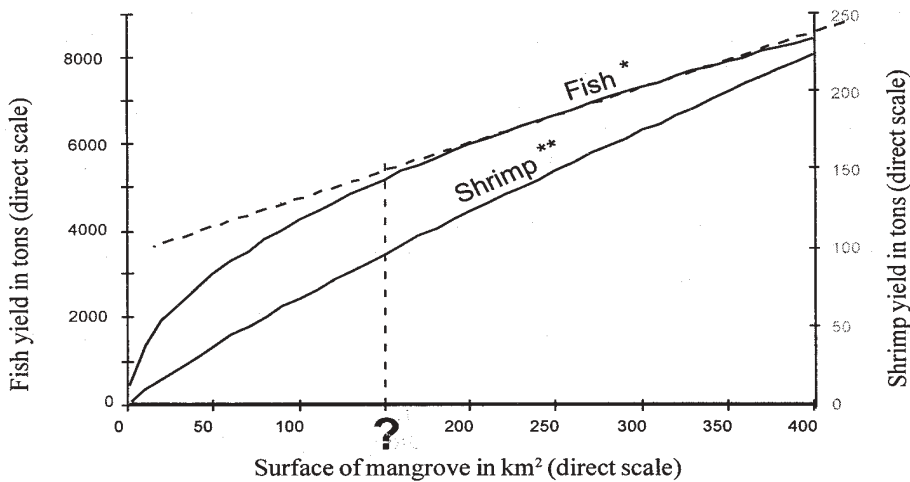


Figure 2. Simulated direct relationships between surface of mangrove (X) and resource harvested (Y). * Yañez-Arancibia *et al.* (1985) ** Paw & Chua (1989)

the total area of coastal vegetation in the Gulf of Mexico, which is mostly mangroves (Figure 1). This is a logarithmic relationship, graphically expressed by a straight line on a log-log scale, but plotting the points on an ordinary scale (Figure 2) shows that this relationship is not linear. Furthermore the shape exhibits an inflexion at a certain abscissa below which a small reduction of surface of mangrove implies a drastic reduction

of the fish production. This also implies that a certain minimum mangrove area is necessary for a high production, as noted by Pauly & Ingles (1986) who suggest that the impact of destruction of a mangrove area might be greater if this area is small and residual.

Yañez-Arancibia *et al.* also demonstrated from the same data that one of the factors exhibiting the strongest correlations with fish

A review of quantified relationships between mangroves and coastal resources.

catches was river discharge, as in temperate regions (Chapman, 1966; Sutcliffe, 1972, 1973).

Regarding mangroves and fisheries, De Graaf & Xuan (1997) showed some correlation between fish catches and mangrove in Vietnam. They considered that 1 hectare of mangrove supported about 500 kg/year of marine catch, but the issues were complicated by significant changes in fishing effort. On the contrary Gilbert & Janssen (1997) reported a rather weak relationship

between commercial fisheries production and mangrove in the Philippines.

**RELATIONSHIPS BETWEEN
MANGROVES AND SHRIMP
RESOURCES**

Fish is a major coastal resource, the other one being shrimp in economical terms. Four

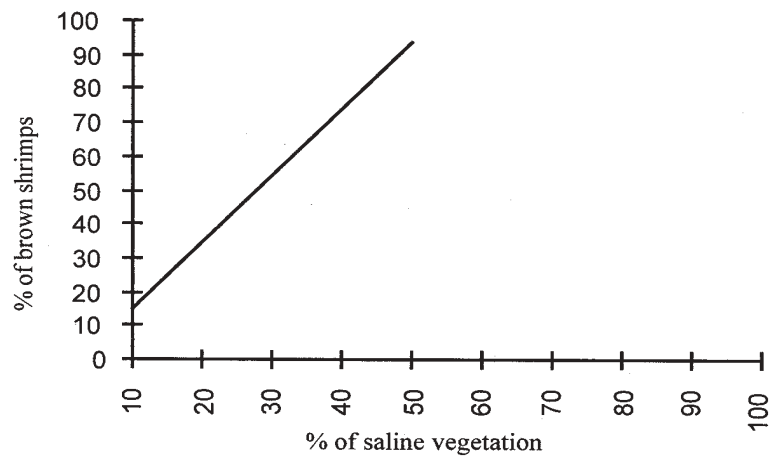


Figure 3. Relationship between the area of saline mangrove marsh in diverse hydrological units (X) and the percentage of brown shrimps in total shrimp catches (Y), after Turner (1977).

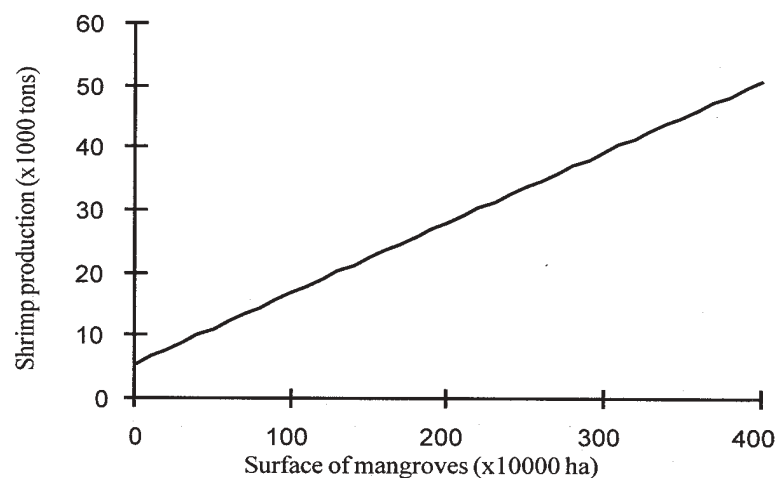


Figure 4. Simulated log-log relationship between surface of mangrove (X) and annual catch of prawns in Indonesia (Y), after Martosubroto & Naamin (1977).

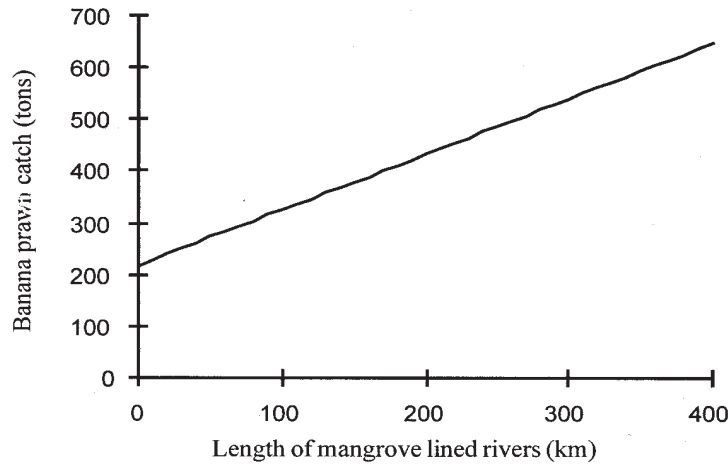


Figure 5. Simulated direct relationship between total length of mangrove lined rivers (X) and the annual catch of banana prawn (Y), after Staples *et al.* (1985)

studies quantify the relationship between mangrove and shrimp production.

In 1977 Turner calculated a positive correlation between shrimp catches and the surface of vegetated estuary in Northeast Gulf of Mexico and in Louisiana (Figure 3). In the latter case, the percentage of brown shrimps in total shrimp catches was significantly proportional to the area of saline mangrove marsh in diverse units. However Chansang (1979) noted biases in the data collection and analyses which might make these results questionable.

In Southeast Asia the first quantified relationship was calculated by Martosubroto & Naamin (1977). These authors show a positive correlation between annual catch of prawns in Indonesia and surface of mangrove (Figure 4). However Chansang (1979) noted that these data also exhibited a negative correlation between the area of tidal forest and the shrimp yield *per area*, *i.e.* the wider the mangrove zone, the lower its productivity.

In the Philippines Paw & Chua (1989) found a positive correlation between the mangrove area and penaeid shrimp catch. This is also a log-log relationship (Figure 1), and above comments on Yañez-Arancibia's curve also apply here (Figure 2). In Australia Staples *et al.* (1985) found a correlation between the total length of mangrove

lined rivers and the annual catch of banana prawn (Figure 5). Finally, Pauly & Ingles (1986) shown that the most important part of the variance of the MSY of penaeids (53% of the variance) could be explained by a combination of area of mangrove habitats and latitude (see Table 1).

CONCLUSION

This study shows that there is a lack of well established quantified relationships between coastal resources yields and area of mangrove. It appears that in spite of a constantly positive relationship between mangrove and commercial fisheries, this is only a **correlation** and the causal link has not been established experimentally (Robertson & Blaber, 1992). At the moment it has not been quantitatively proven that mangrove is the **causal** factor, compared to other factors related to mangrove such as extensive shallow seas, intertidal area, tidal creeks or length of coastline.

Furthermore any real statement on "production" expressed in terms of commercial catches should integrate the number of shrimping vessels and time spent out at sea (fishing effort). If not, most of data on catches could only show a proportionality between surface of mangrove, surface of fishing zones and number of fishing

boats. However these estimates based on commercial catches will always be global, aggregating fishery production on the one hand, and assuming uniformity of mangrove, in terms of any nursery function for instance, on the other. This may not be the case (Hambrey, 1996, 1997). Apart from productivity it seems to be important to determine, for a given local fishery, the real dependency of fish resources on the mangrove environment: is the mangrove zone essential for a given species; what are its trophic or reproductive relationships with this zone; are there alternative areas for its development?

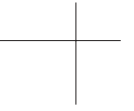
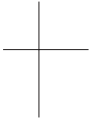
In Southeast Asia a detailed analysis of current capture data as a function of mangrove area could be approached in terms of a comparative

study (several punctual data in different locations) or a temporal study (several samples in time in a given location). Such studies seem to be possible thanks to current fisheries data such as data compiled by FAO, ICLARM, national Departments of Fisheries, and recent remote sensing data on mangrove surfaces such as that of Spalding *et al.* (1996). Several studies led in Thailand and Africa (Ikenoue *et al.*, 1990; Baran, 1995; Diouf, 1996; Laroche *et al.*, 1997) show that a statistical multivariate approach could efficiently address this concern. Then an accurate valuation of these mangrove areas is likely to be relatively straightforward in economic terms, providing a better basis for management decisions.

BIBLIOGRAPHY

- Baran, E. 1995. Dynamique spatio-temporelle des peuplements de poissons estuariens en Guinée - relations avec le milieu abiotique- ("Spatio-temporal dynamics of estuarine fish assemblages in Guinea -relationships with abiotic factors-"). TDM 142, 236 pp. Editions ORSTOM, Paris. Available on Internet at <http://limnologie.univ-lyon1.fr/~baran/>
- Blaber, S. J. M. 1997. Fish and fisheries of tropical estuaries. Fish and fisheries series, Chapman & Hall, London.
- Chansang, H. 1979. Correlation between commercial shrimp yields and mangroves. **In:** Proceedings of the 3rd national seminar on mangrove ecology, Songkhla University, Hat Yai. 2: 744-753
- Chapman, C. R. 1966. The Texas basins projects. **In:** Smith R., Swartz A., Massmann (eds.) Symposium on estuarine fisheries. Am. Fish. Society Spec. Publ. no 3: 83-92
- Chua, T.E. and D. Pauly. (eds.) 1989. Coastal area management in Southeast Asia: policies, management strategies and case studies. ICLARM Conference Proceedings. 19: 254 pp.
- De Graaf, G. J. and T.T. Xuan. 1997. Shrimp farming and natural fisheries in the southern provinces of Vietnam. Report for the Coastal Wetlands Protection and Development Project, Ho Chi Minh City, Vietnam.
- Diouf, P. S. 1996. Les peuplements de poissons des milieux estuariens de l'Afrique de l'Ouest: l'exemple de l'estuaire hyperhalin du Sine Saloum. Thèse de doctorat, Université de Montpellier. 2: 267 pp.
- Gilbert, A.J. and R. Janssen. 1997. The use of environmental functions to evaluate management strategies for the Pagbilao mangrove forest. IIED CREED No 15. Working Paper Series Institute for Environmental Studies, Vrije University, Netherlands.
- Hambrey, J. 1996. Comparative economics of land use options in the mangrove. *Aquaculture Asia* Vol 1(2): 10-14.
- Hambrey, J. 1996. The mangrove questions. *Asian Shrimp News*, 26. 2nd Quarter 1996
- Ikenoue, H., S. Chullasorn., S. Yoosooksawat and W. Thubthimsang. 1990. Multivariate analysis of fisheries statistics in the Eastern part of the Gulf of Thailand. *Thai Mar. Fish. Res. Bull.* 1: 3-34

- Laroche, J., E. Baran and N.B. Rasoanandrasana. 1997. Temporal patterns of a fish assemblage in a semi-arid mangrove zone (Madagascar). *J. Fish Biol.* **51**: 3–20.
- Martosubroto, P. and N. Naamin. 1977. Relationship between tidal forests (mangroves) and commercial shrimp production in Indonesia. *Marine Research in Indonesia*. **18**: 81–86.
- Pauly, D. and J. Ingles. 1986. The relationship between shrimp yields and intertidal vegetation (mangrove) areas: a reassessment. **In**: IOC/FAO workshop on recruitment in tropical coastal demersal communities, Ciudad de Carman, Mexico, 21–25 April 1986. pp. 227–284. IOC, Unesco Paris.
- Paw, J. N. and T. E. Chua. 1989. An assessment of the ecological and economic impact of mangrove conversion in Southeast Asia. *Mar. Pollut. Bull.*, **20**(7): 335–343.
- Robertson, A. I. and S.J.M. Blaber. 1992. Plankton, epibenthos and fish communities. **In**: A. Robertson and D. Alongi (eds.) “Tropical mangrove ecosystems”, pp. 173–224. American Geophysical Union, Washington, D.C.,
- SEAFDEC. 1997. Proceeding of the Regional workshop on coastal fisheries management based on Southeast Asian experiences. Chiang Mai, 19–22 November 1996. Training department, South East Asian Fisheries Development Center, Samut Prakarn, Thailand.
- Spalding, M.D., F. Blasco and C.D. Field. 1996. World mangrove atlas. International Society for Mangrove Ecosystems, Okinawa, Japan.
- Staples, D.J., D.J. Vance and D.S. Heales. 1985. Habitat requirements of juvenile penaeid prawns and their relationship to offshore fisheries. **In**: Rothlisberg P.C., Hill B.J., Staples D.J. (eds.). Second Australian national prawn seminar, Kooralbyn (Australia), pp. 47–54.
- Sutcliffe, W. H. 1972. Some relations of land drainage, nutrients, particulate material and fish catch in two eastern Canadian bays. *J. Fish. Res. Board Canada*, **29**(4): 357–362.
- Sutcliffe, W. H. 1973. Correlations between seasonal river discharge and local landings of American lobster (*Homarus americanus*) and Atlantic halibut (*Hippoglossus hippoglossus*) in the Gulf of St Lawrence. *J. Fish. Res. Board Canada*, **30** (6): 856–859.
- Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimps. *Trans. Am. Fish Soc.* **106**: 411–416
- Twilley, R. R., S.C. Snedaker, A. Yañez-Arancibia and E. Medina. 1996. Biodiversity and ecosystem processes in tropical estuaries: perspective of mangrove ecosystems. **In**: Mooney *et al.* (eds.). Functional roles of biodiversity: a global perspective. pp. 327–370. John Wiley & Sons Ltd.
- Yañez-Arancibia, A., G. Soberon-Chavez and P. Sanchez-Gil. 1985. Ecology of control mechanisms of natural fish production in the coastal zone. **In**: Yañez-Arancibia (ed.): Fish community ecology in estuaries and coastal lagoons ; towards an ecosystem integration. pp. 571–595. UNAM Press, Mexico.



A review of quantified relationships between mangroves and coastal resources.

