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A REVIEW OF QUANTIFIED RELATIONSHIPS BETWEEN MANGROVES AND COASTAL RESOURCES.

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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.

1) 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 in Table I.

2) 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 the total area of coastal vegetation in the Gulf of Mexico, which is mostly mangroves (Fig. 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 (Fig. 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 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.

3) Relationships between mangroves and shrimp resources

Fish is a major coastal resource, the other one being shrimp in economical terms. Four 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 (Fig. 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 (Fig. 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 (Fig. 1), and above comments on Yañez-Arancibia's curve also apply here (Fig. 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 (Fig. 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 I).

4) Conclusion

This study shows that there is a lack of well established quantified relationship 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 surface area 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.

5) Bibliography

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Table I: Quantified relationships between mangroves and coastal resources

Reference	Formula	X	Y	r^2	n
Yañez-Arancibia et al. (1985)	Ln Y = 0.496 Ln X + 6.070	Coastal marshes in km2	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
	No equation given	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	Log_{10} of mangrove area	Log_{10} of penaeid shrimp catch (tons)	0.66	17
Staples et al. (1985)	Y = 1.074 X +218.3	Mangrove shoreline (Km)	Banana prawn catch (tons)	0.58	6
Pauly & Ingles (1986)	$Log_{10}MSY = 0.4875 log_1$ AM - 0.0212L + 2.41	MSY = Maximum Sustainable Yield of penaeids AM = area of mangroves L = degrees of latitude			

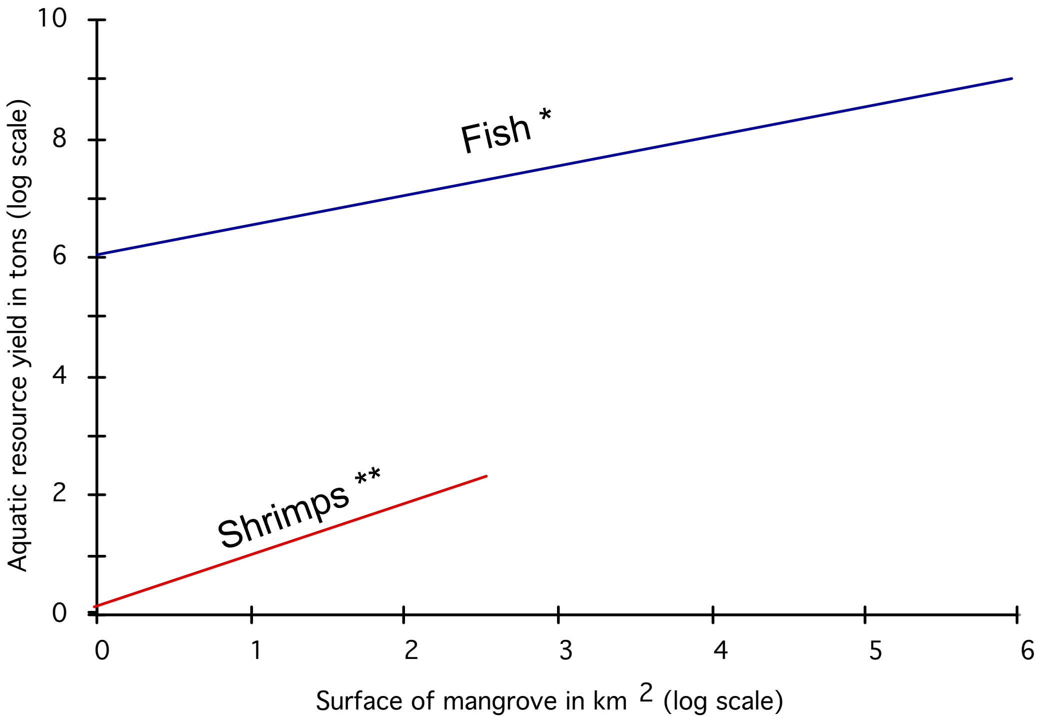

Figure 1: Simulated log-log relationships between surface of mangrove (Ln X) and resource harvested (Ln Y).
* Yañez-Arancibia et al. (1985) ** Paw & Chua (1989)

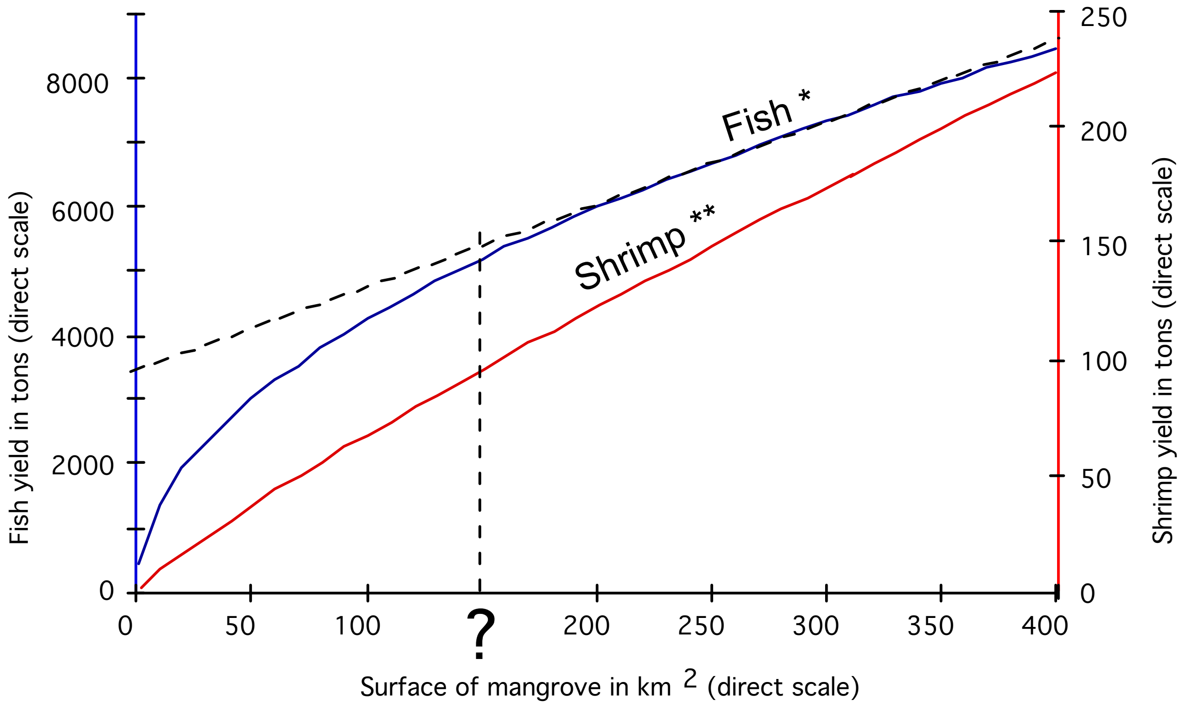

Figure 2: Simulated direct relationships between surface of mangrove (X) and resource harvested (Y).
* Yañez-Arancibia et al. (1985) ** Paw & Chua (1989)

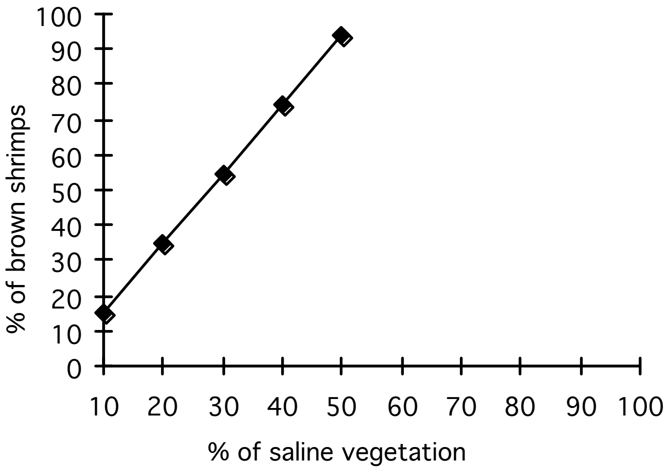

Figure 3: Relationship between the area of saline mangrove marsh in diverse hydrological units (X) and the percentage of brown shrimps in total shrimp catches (Y), after Turner (1977).

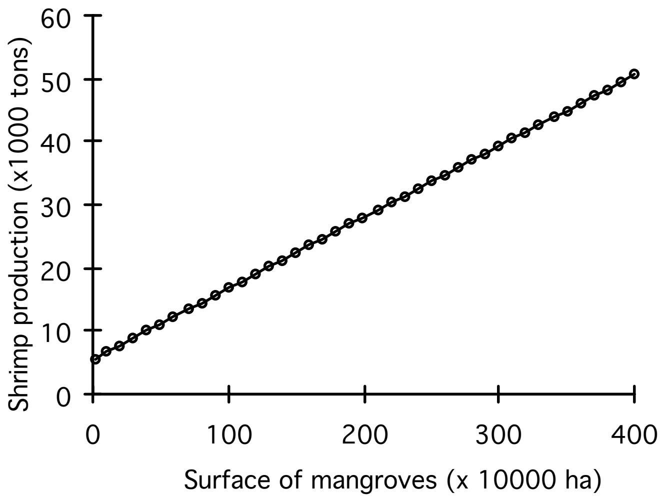

Figure 4: Simulated log-log relationship between surface of mangrove (X) and annual catch of prawns in Indonesia (Y), after Martosubroto & Naamin (1977).

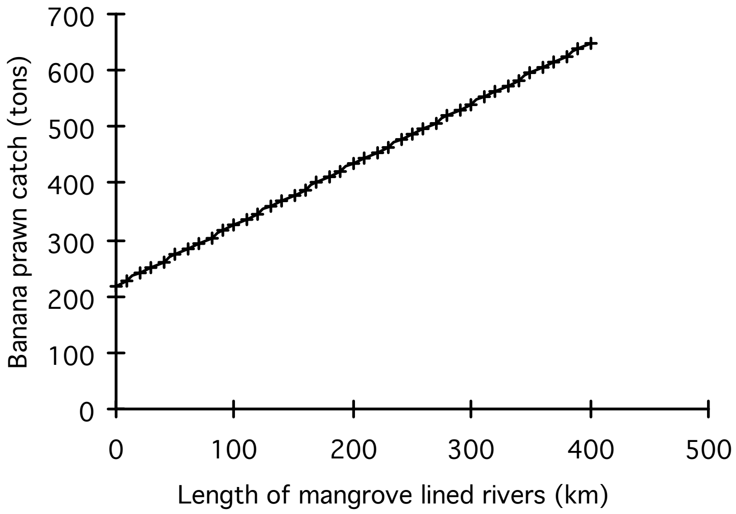

Figure 5: Simulated direct relationship between total length of mangrove lined rivers (X) and the annual catch of banana prawn (Y), after Staples et al. (1985)