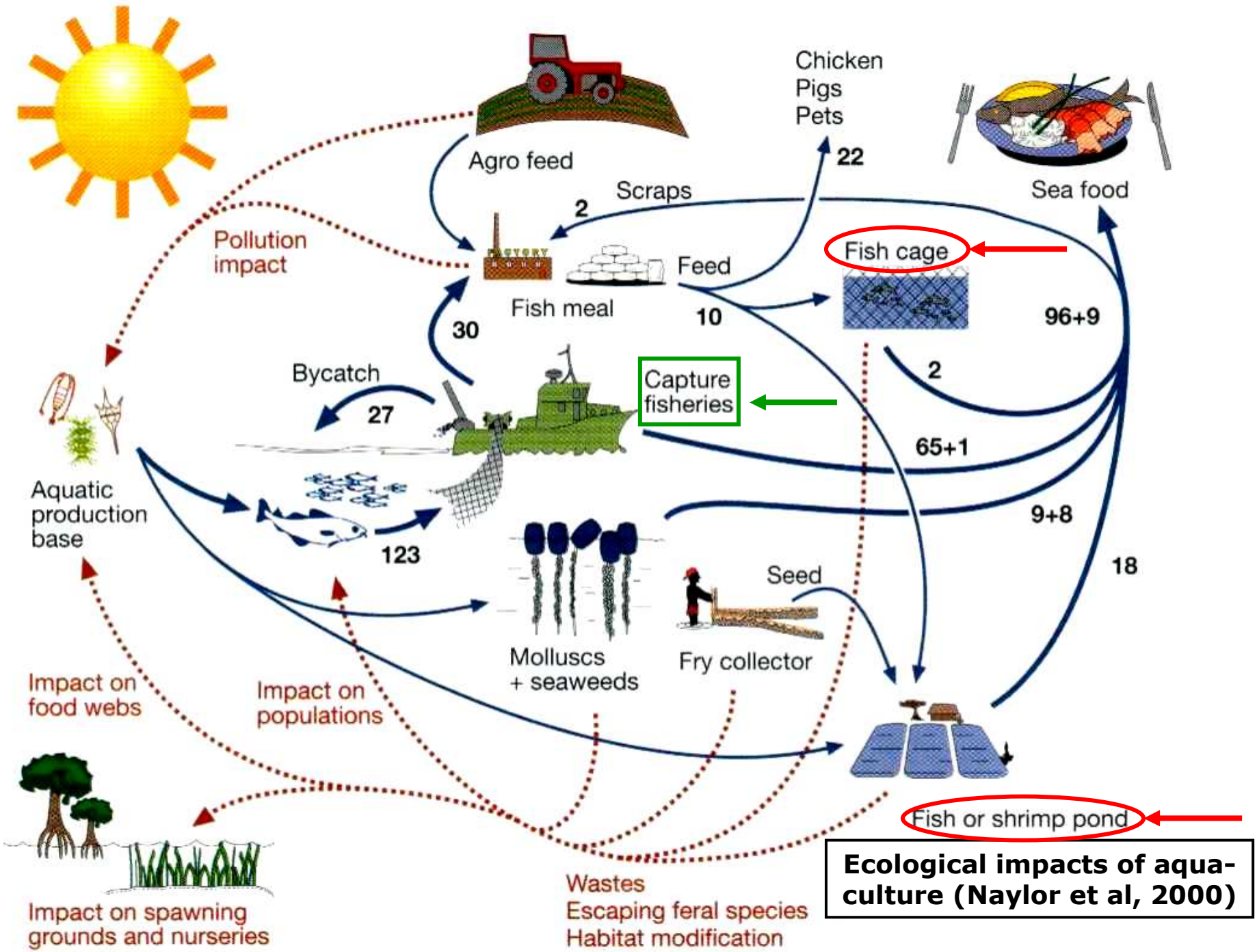
INTEGRATION OF MANGROVES AND AQUACULTURE

J.H. Primavera
SEAFDEC Aquaculture Department
Tigbauan, Iloilo, Philippines

- Aquaculture
- Mangroves
- Are they compatible?
  - Mangrove-Friendly Aquaculture in Asia
  - Mangroves as aquaculture filters
  - Mud crab culture in mangrove pens
- Mangrove rehabilitation (typhoons, sealevel rise)

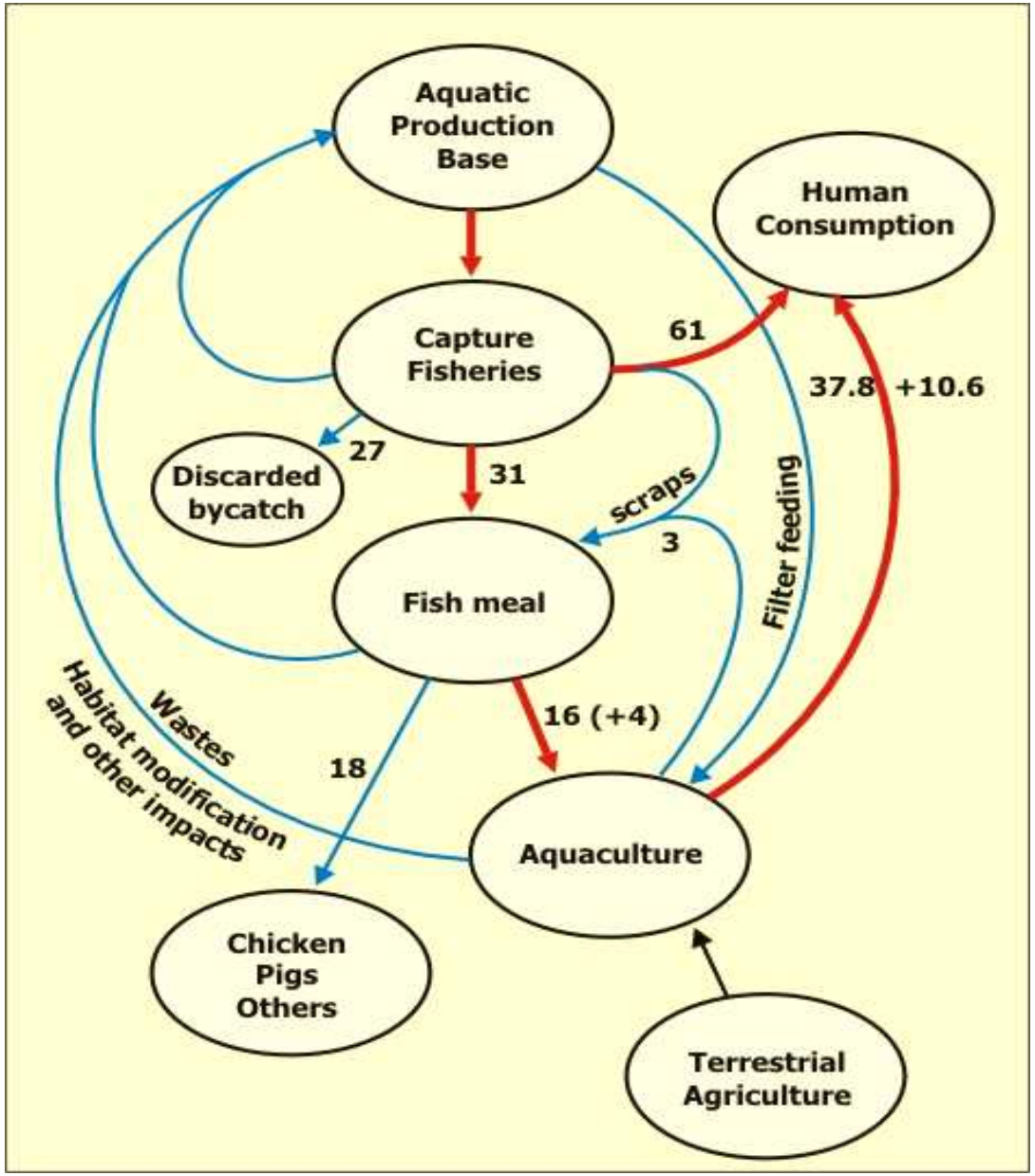
ASIAN AQUACULTURE SPECIES/SYSTEMS

Group		System	Method
Plants:	*Eucheuma*, *Gracilaria* *Laminaria*	longlines, rafts, fixed bottom	extensive
Molluscs:	oyster, mussel, scallops	rafts, longlines, stakes	extensive
Crustaceans:	prawns/shrimps, crabs	ponds	extensive, semi-intensive, intensive
Marine/brackishwater fish:	milkfish, tilapia, grouper, snapper	pens, cages, ponds	extensive, semi-intensive, intensive
Freshwater fish:	tilapia carps, catfish	ponds, cages, pens	polyculture, intensive



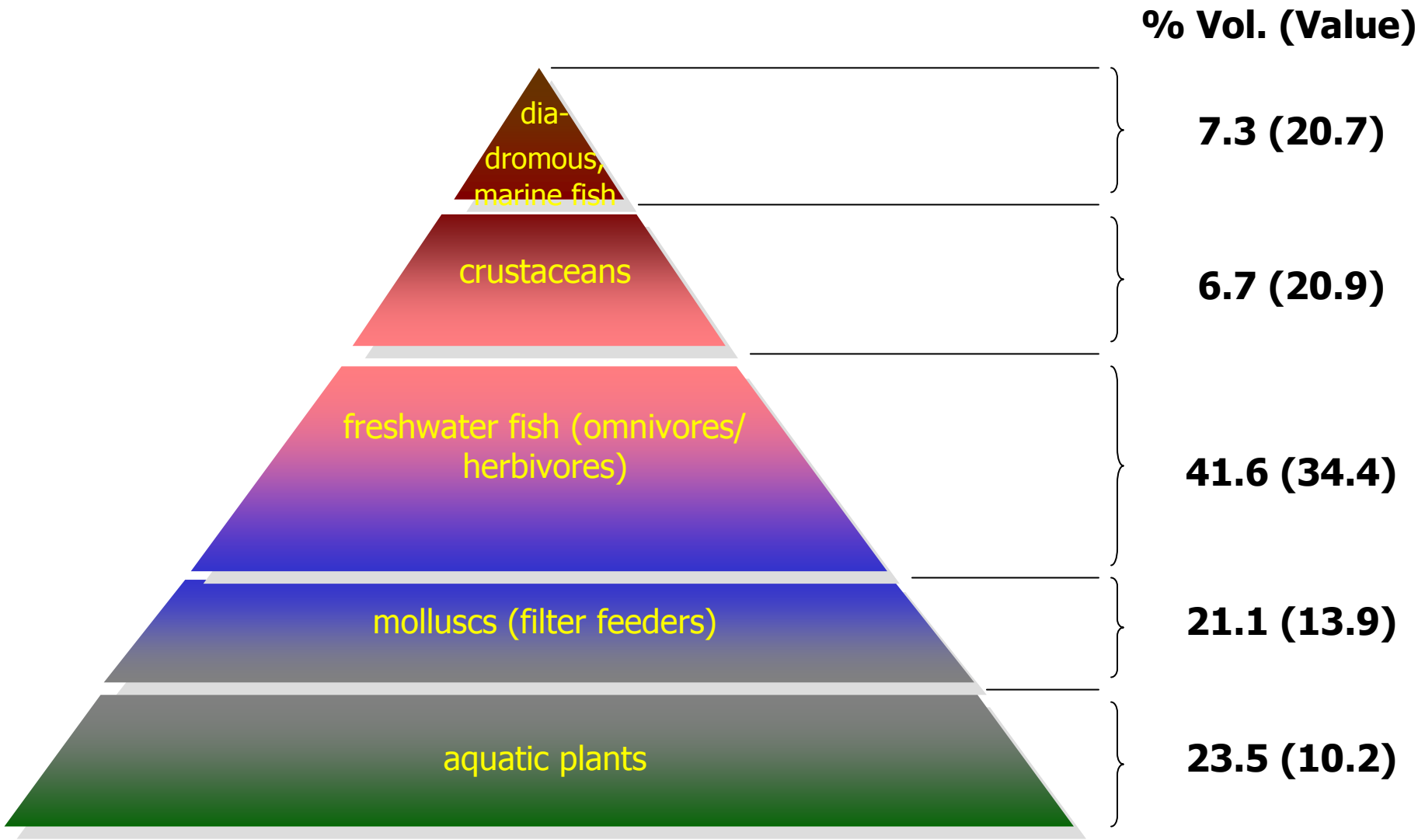
Ecological impacts of aqua-culture (Naylor et al, 2000)

AQUACULTURE DEPENDENCE ON WILD FISH SUPPLIES



Flow chart of capture and farmed fisheries products from aquatic primary production (in 2001 million metric tons of fish = 48.4 Mmt tot.) (Naylor et al, 2000)

2006 Aquaculture Production
(85.9 million mt, US$66.7 billion)

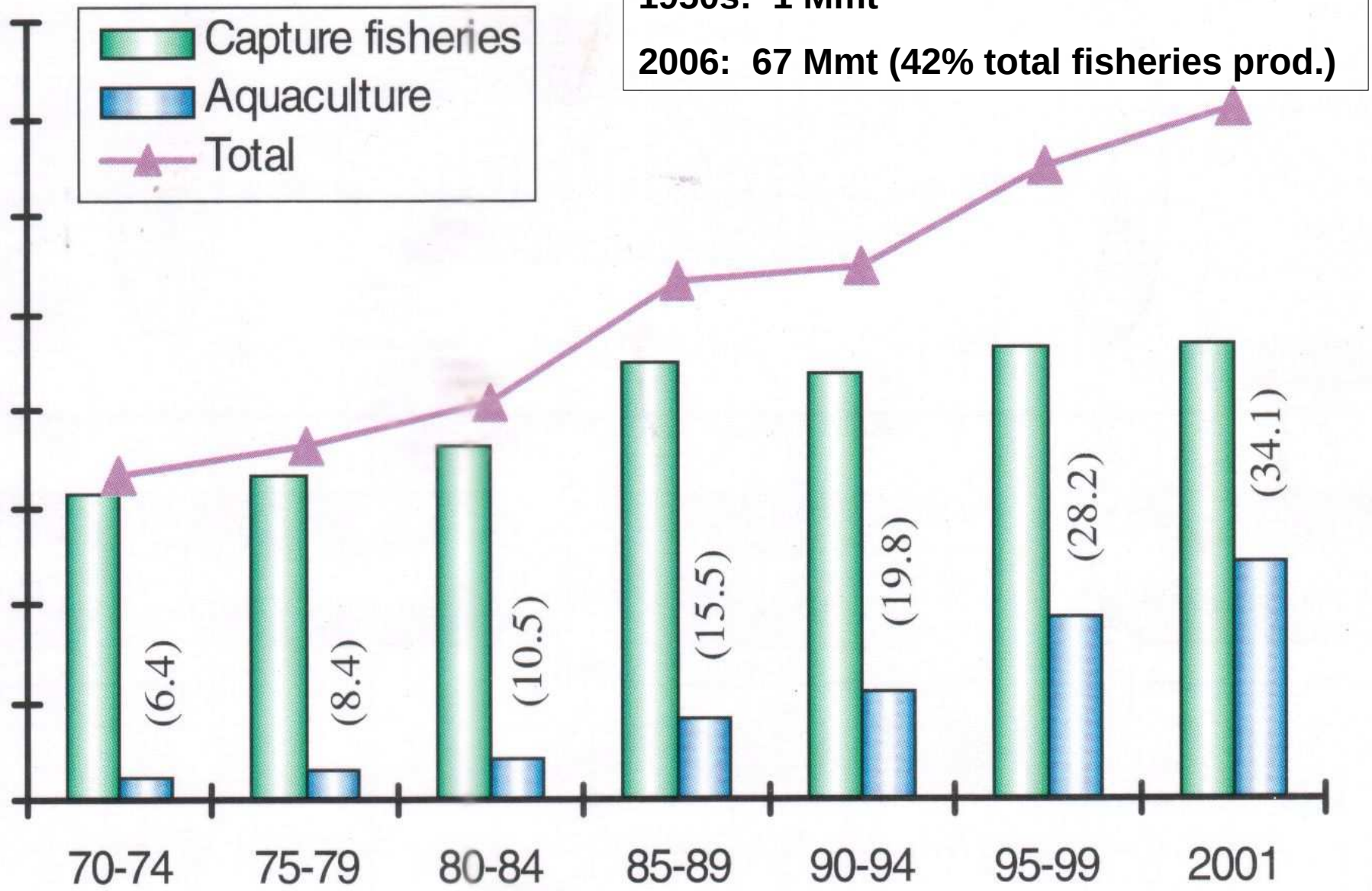


Source: FAO Yearbook 2006

World Aquaculture Production

1950s: 1 Mmt

2006: 67 Mmt (42% total fisheries prod.)



Philippine fisheries production

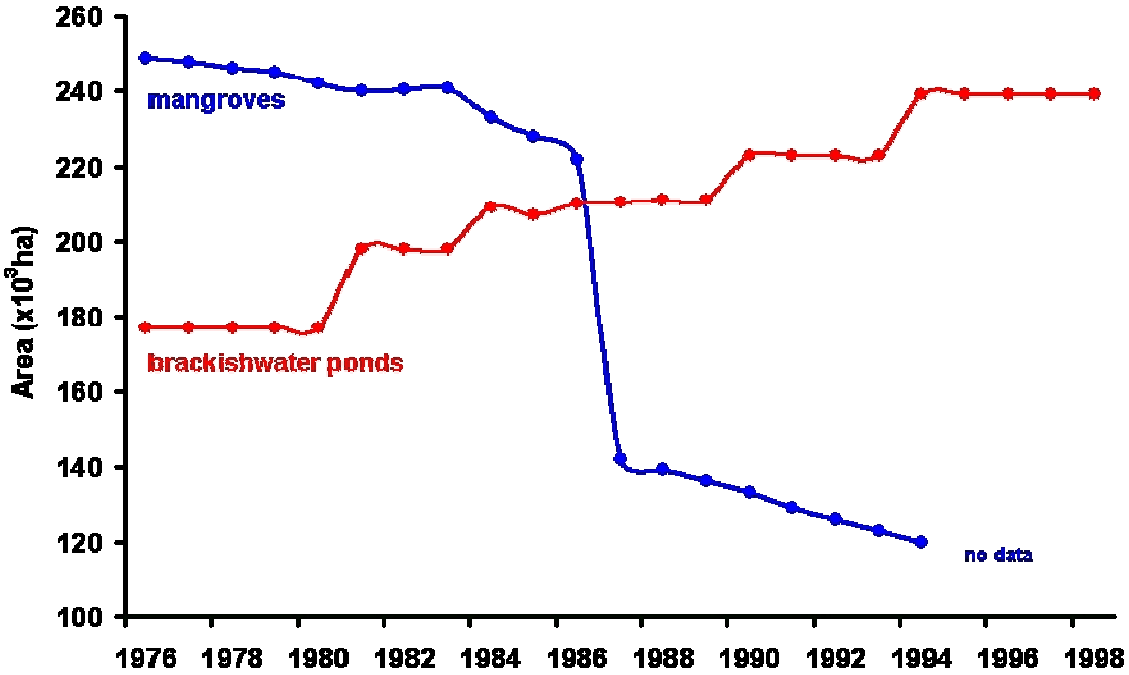
ENVIRONMENTAL IMPACTS

1) Habitat (mangroves) loss/modification
2) Introduction of exotic species
3) Spread of pests and diseases
4) Salinization of soil and water
5) Dependence on fishmeal
6) Misuse of antibiotics and chemicals
7) Loss of bycatch of wild fry/broodstock
8) Pollution/eutrophication of receiving waters

PHILIPPINES

MANGROVES	PONDS
1918: 500,000 ha	1940: 61,000 ha
1994: 120,000 ha	1994: 232,000 ha

MANGROVE: POND RATIO 0.5:1



SE ASIAN MANGROVES & SHRIMP CULTURE

SE Asia	Shrimp ponds (ha)[a]	Mangroves (ha)[b]	% Mangrove loss (30 yr)[c,d]
Brunei Darussalam	--	17,100	--
Cambodia	--	60,100	--
Indonesia	350,000	4,542,100	32 – 45
Malaysia	4,000	642,400	25 – 32
Myanmar	--	378,600	--
Philippines	60,000	160,700	40 – 80
Thailand	200,000	264,100	50 – 70
Vietnam	200,000	252,400	--
Total	814,000	6,317,500	
% world total	65	35	

MANGROVES & SHRIMP CULTURE IN SOUTHEAST ASIA

World Total:
16-18 M ha mangroves
1.25 M ha fish/shrimp ponds

GLOBAL (Valiela et al., 2001)

54% - total present area represented in study
2.1% - yearly loss of existing area
35% - average loss since 1980s
52% - loss due to shrimp and fish culture

CHOKARIA SUNDERBANS

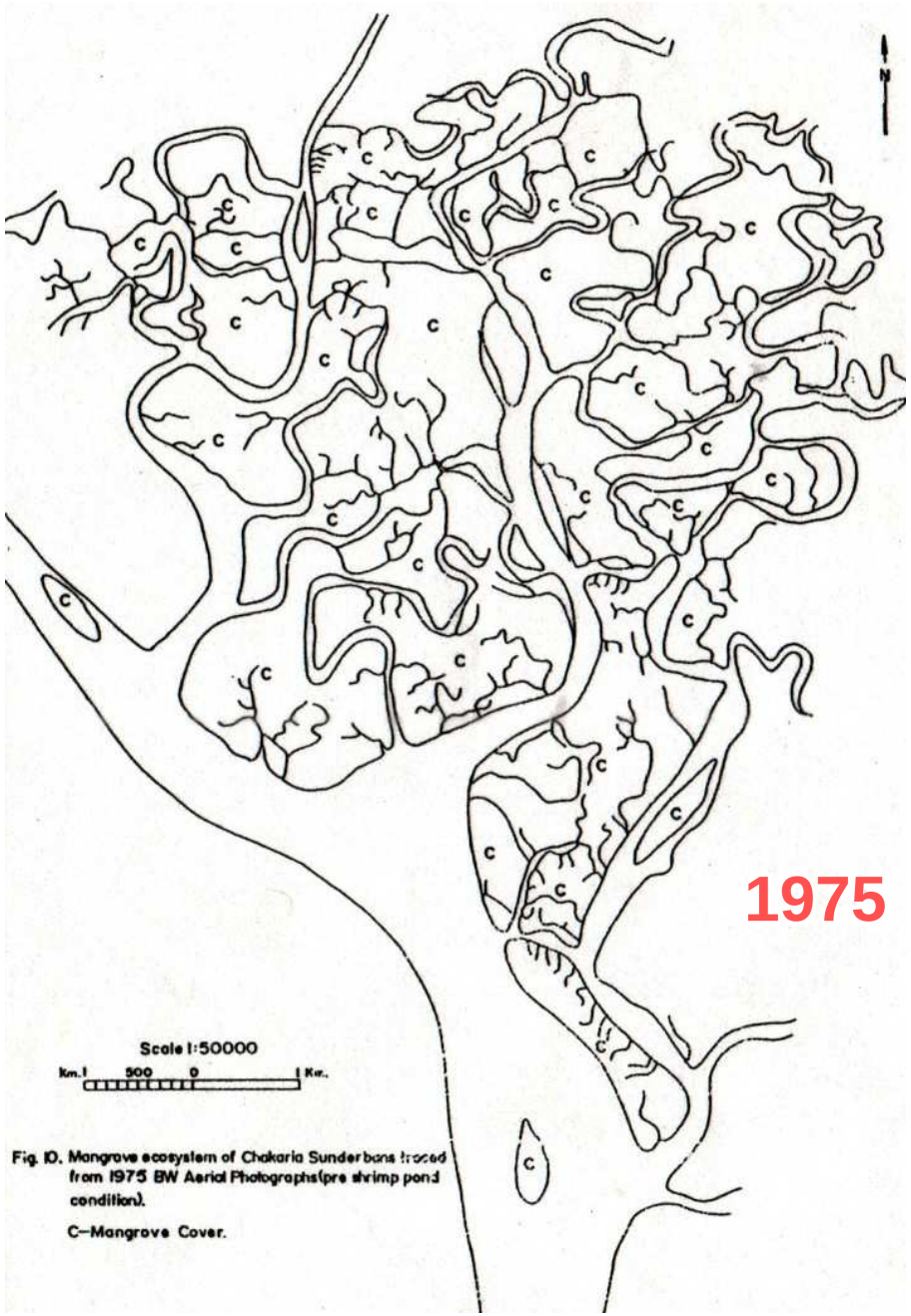
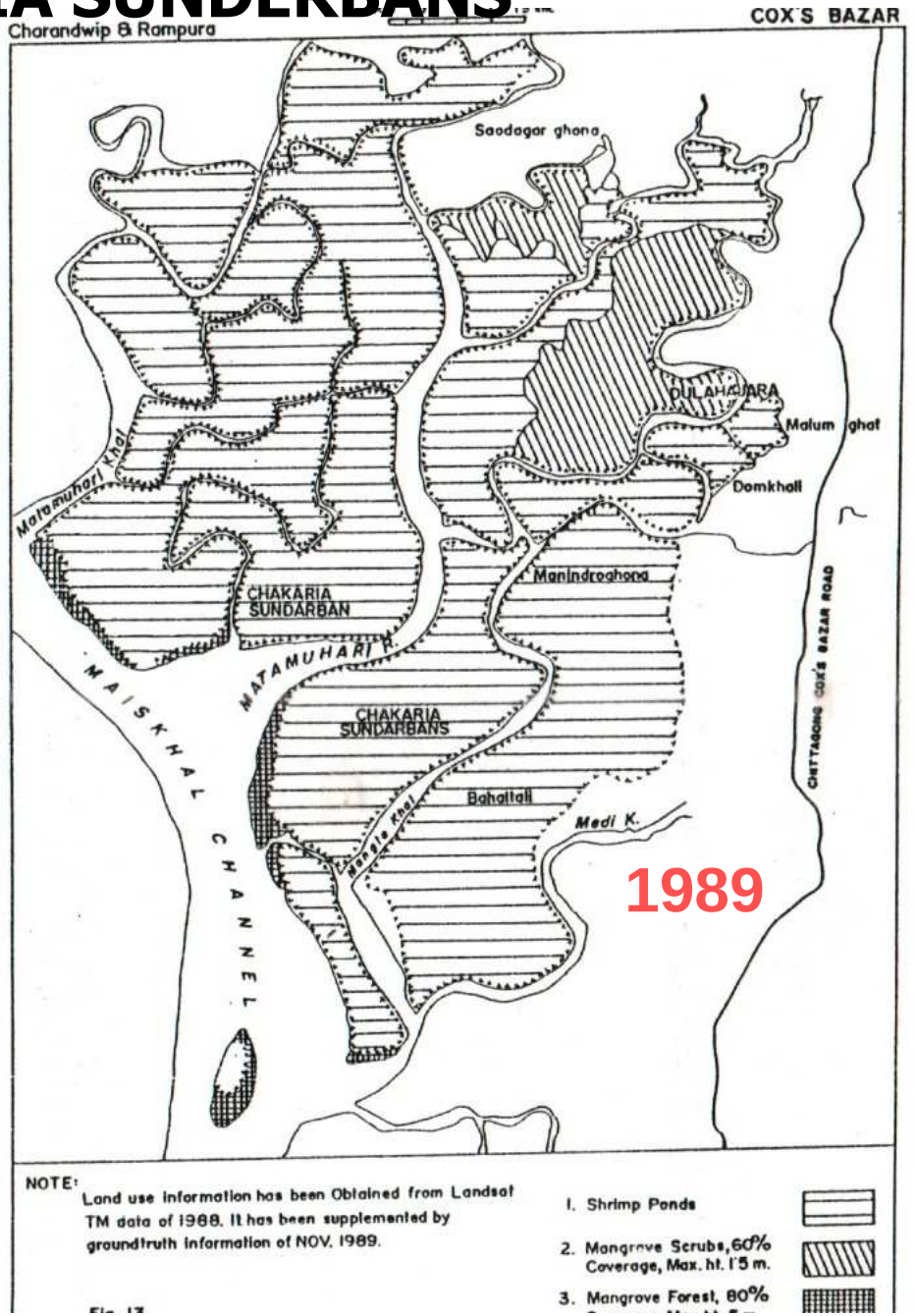
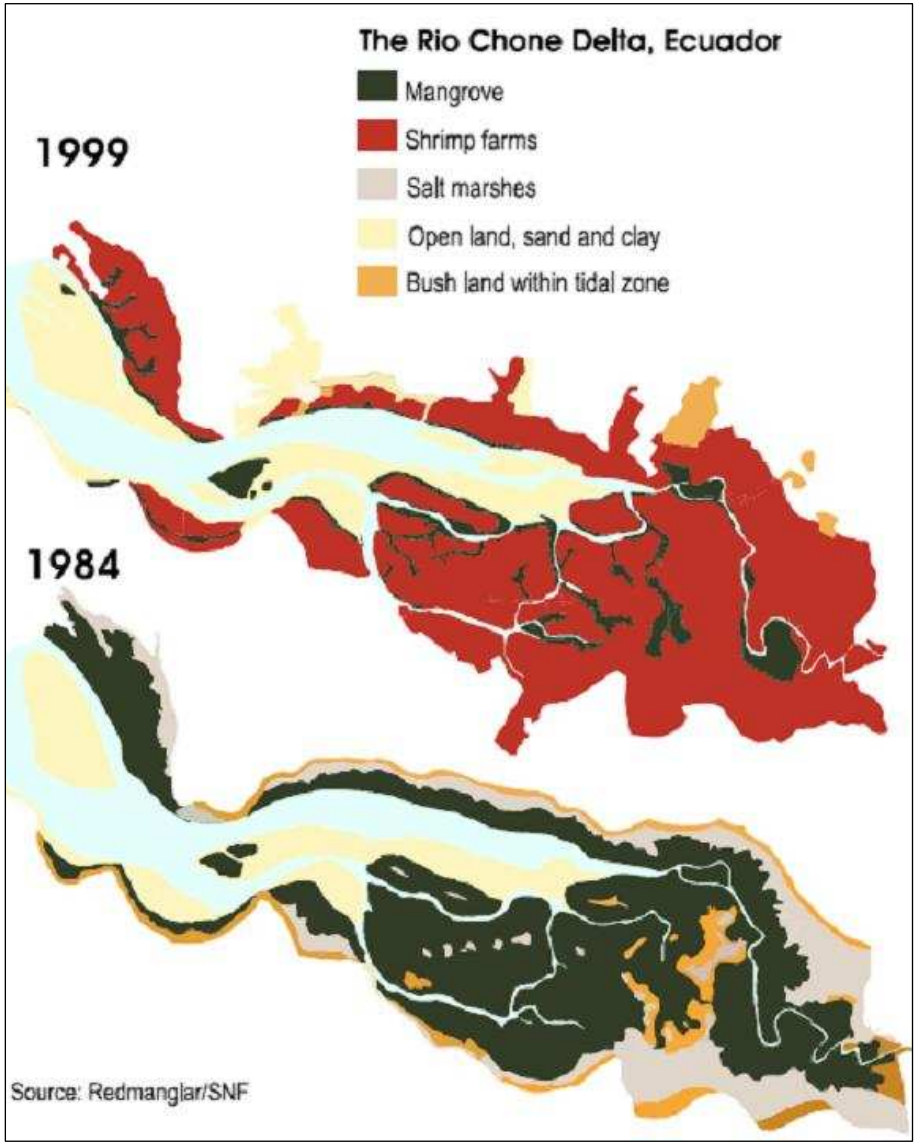


Fig. 10. Mangrove ecosystem of Chakaria Sunderbans traced from 1975 BW Aerial Photographs(pre shrimp pond condition).

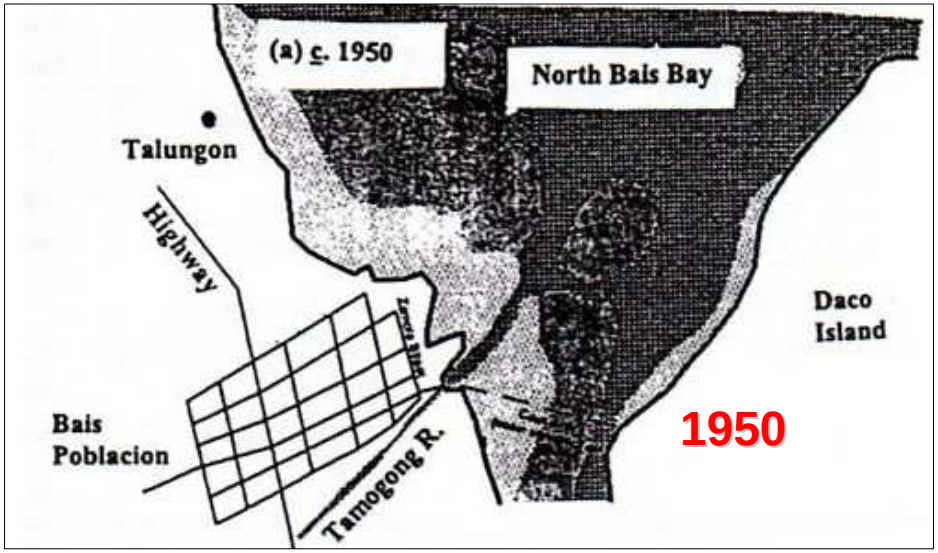
C–Mangrove Cover.

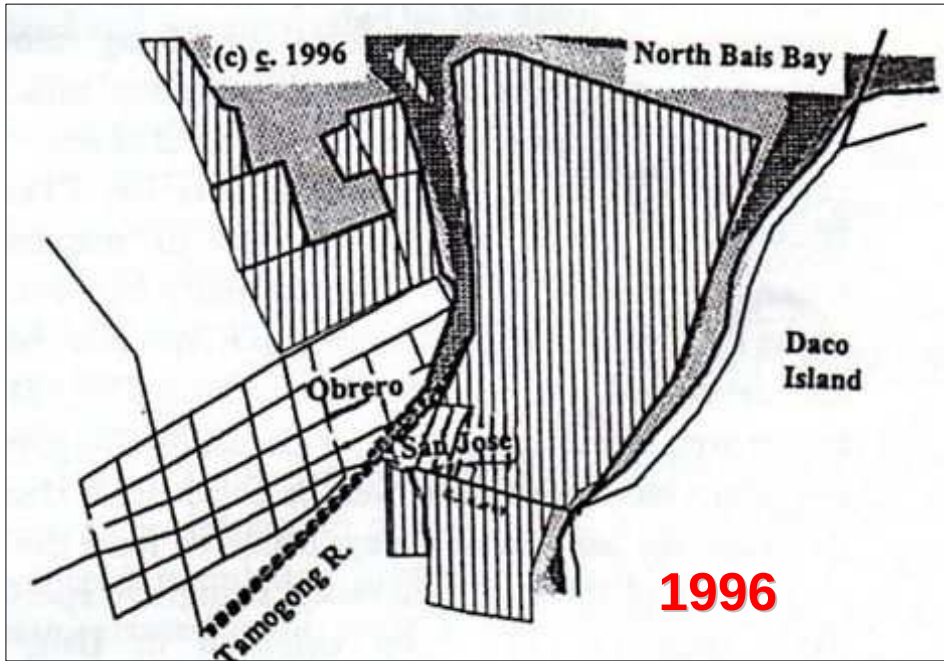


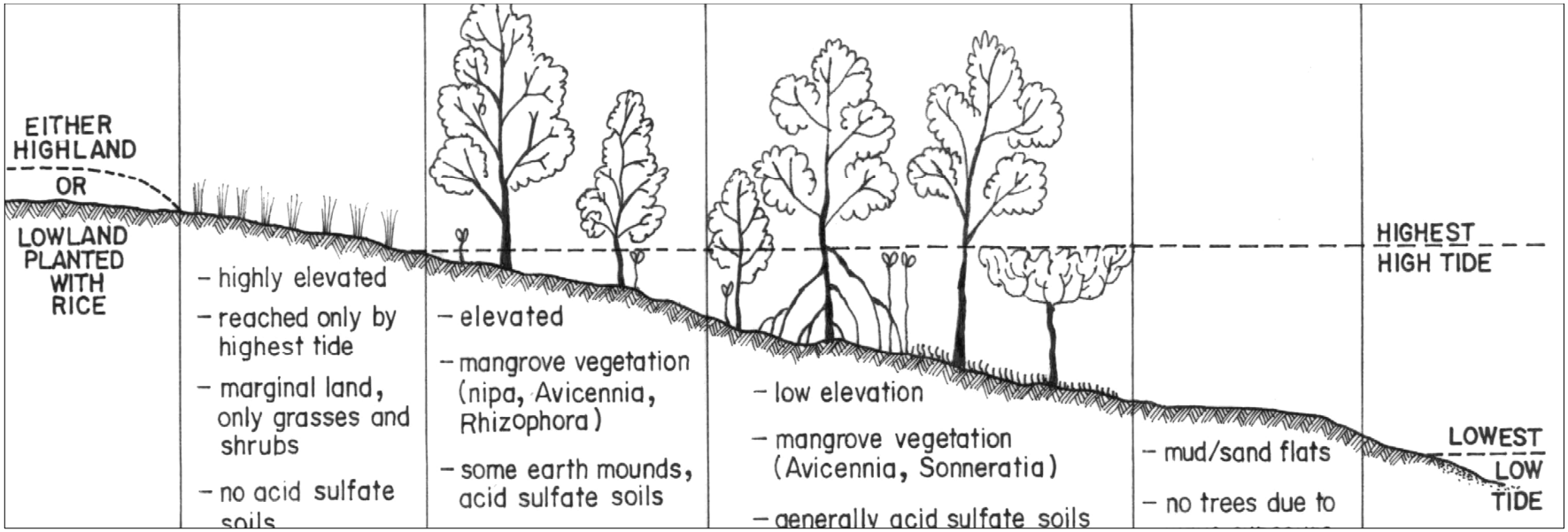
Rio Chone Delta, Ecuador (Redmanglar SNF)



North Bais Bay, Negros Or., Philippines (Walters, 1996)





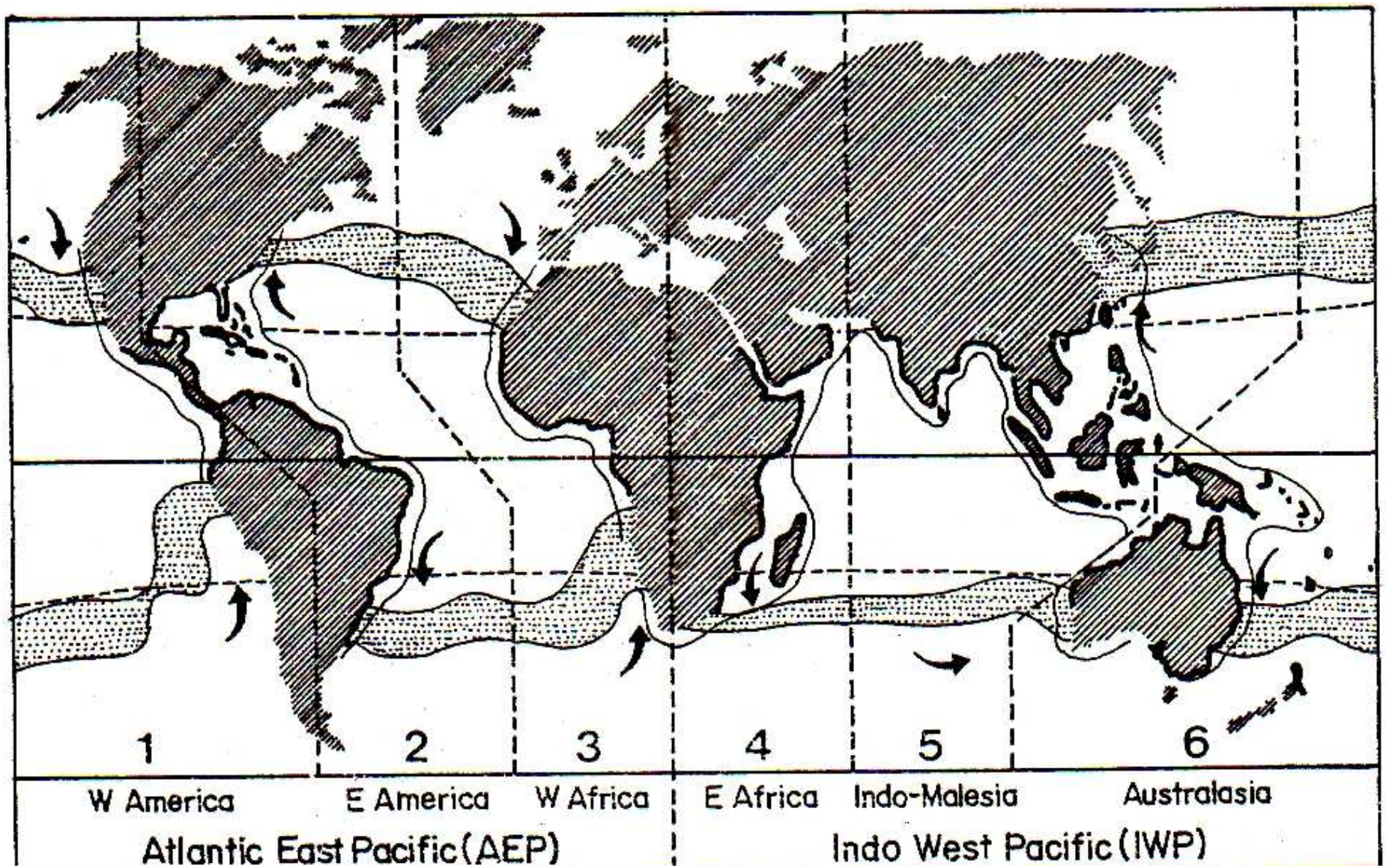


Carbine (1932): "Mangrove … swamps are **ideal for fishpond sites.** Most of [these] are removed … only a few should be left for shade"

Carbine (1948): "… the bangos [milkfish] industry is important because it made use of … practically **valueless [mangrove]** land."

Ling (1977): "Aquaculture has … served to reclaim largely **unproductive** land.Thousands of hectares of mangrove swamps … have been converted into productive fishponds …"

BIOGEOGRAPHICAL DISTRIBUTION OF MANGROVES (Duke, 1994)



FIELD GUIDE TO PHILIPPINE MANGROVES

by J.H. Primavera, Ph.D.

Mangrove species in this field guide are sorted by genera. Close-up photographs of distinctive features (leaves, flowers, fruits, bark, roots) are provided for visual comparison to facilitate identification of species. of species. A taxonomic key on the back page provides more details on features and measurements of leaves, flowers, etc.

PEW FELLOWS PROGRAM IN MARINE CONSERVATION

Acanthus Family Acanthaceae

Acanthus ebracteatus *Acanthus ilicifolius* *Acanthus volubilis*

Local names: lagiwliw, ragoyroy

Avicennia Family Avicenniaceae

Local names: bungalon, apiapi, miapi

Avicennia alba

Silvery undersurface of leaves; black or sooty bark

Avicennia marina

Flaky light green to light brown bark

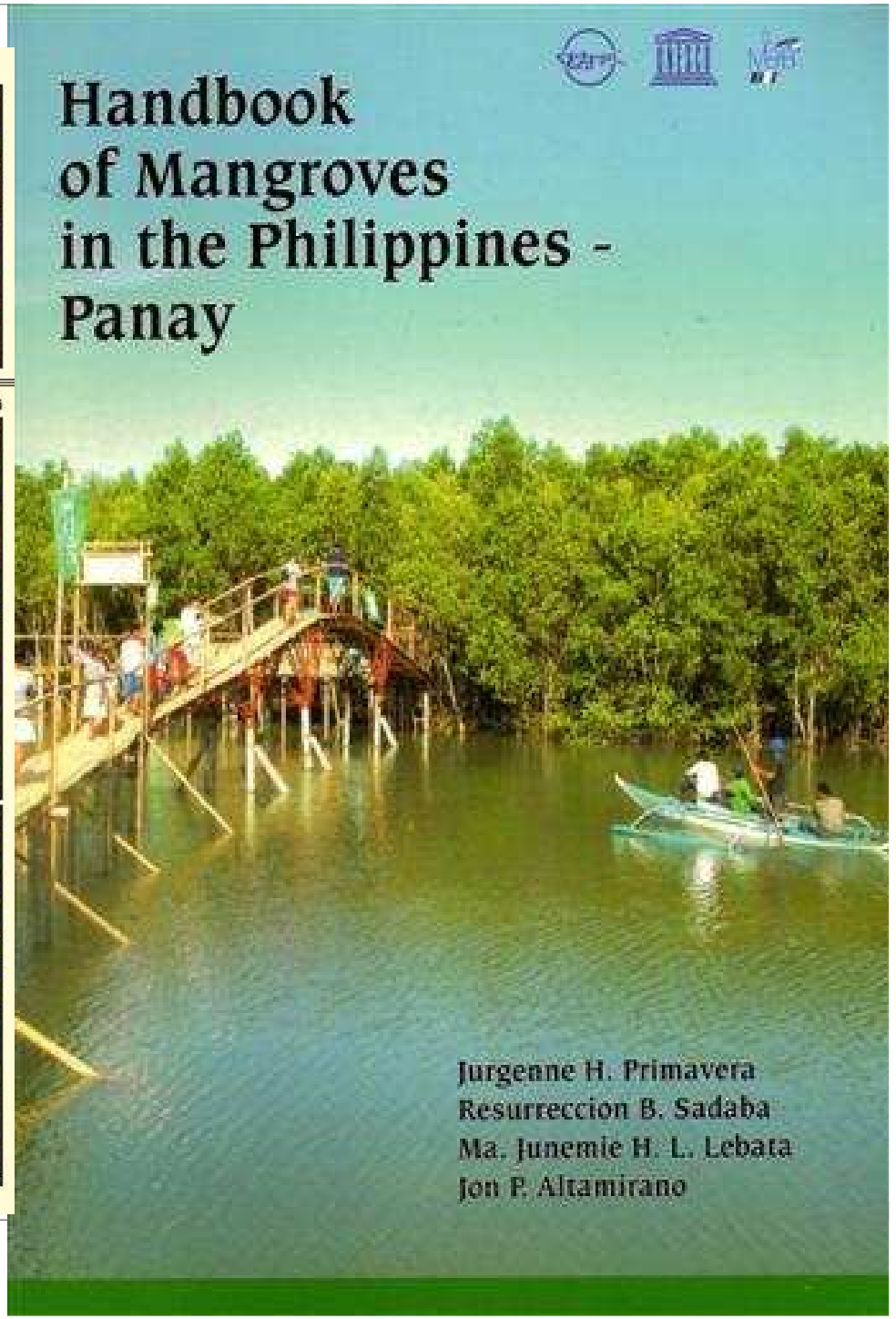
Avicennia officinalis

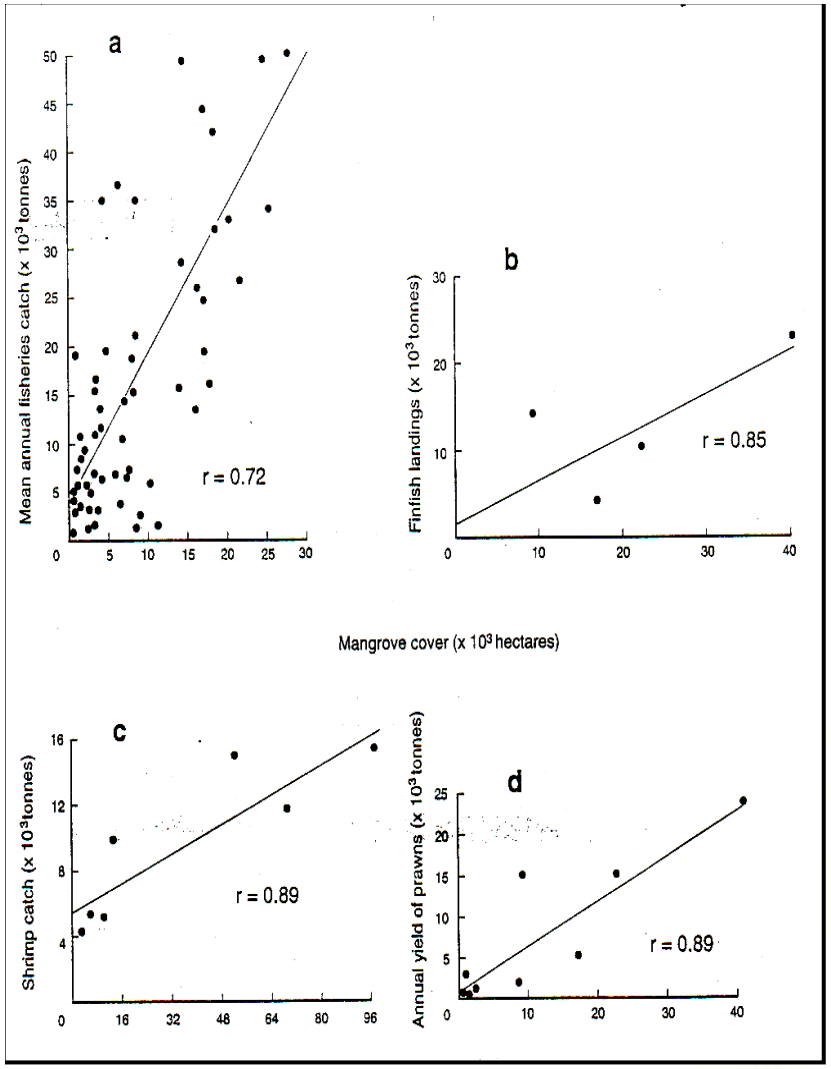
Leaves shiny, sometimes with salt crystals

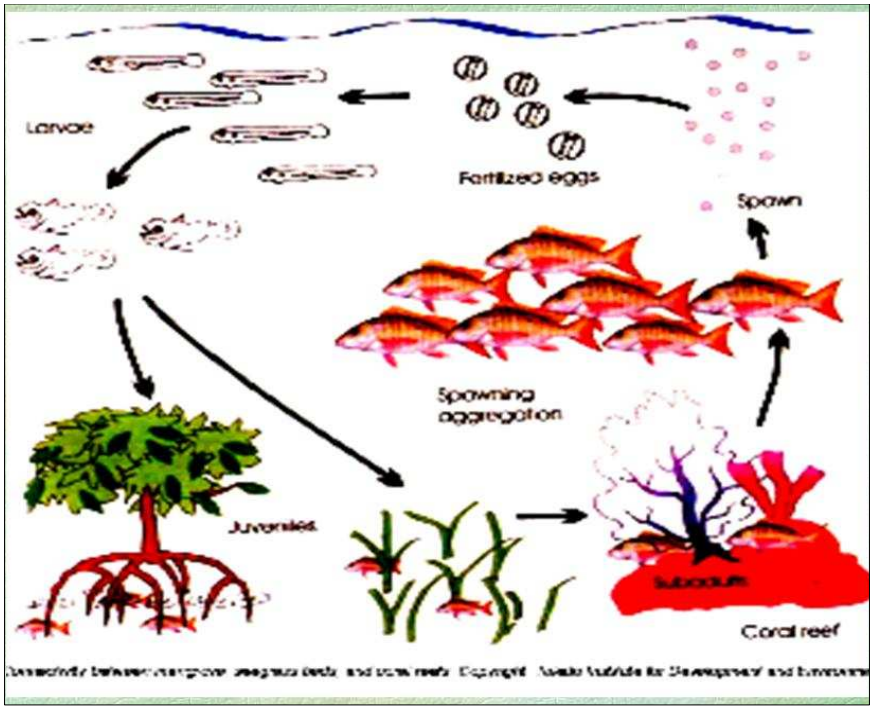
Avicennia rumphiana

Hairy, brownish leaf undersurface, hairy fruits

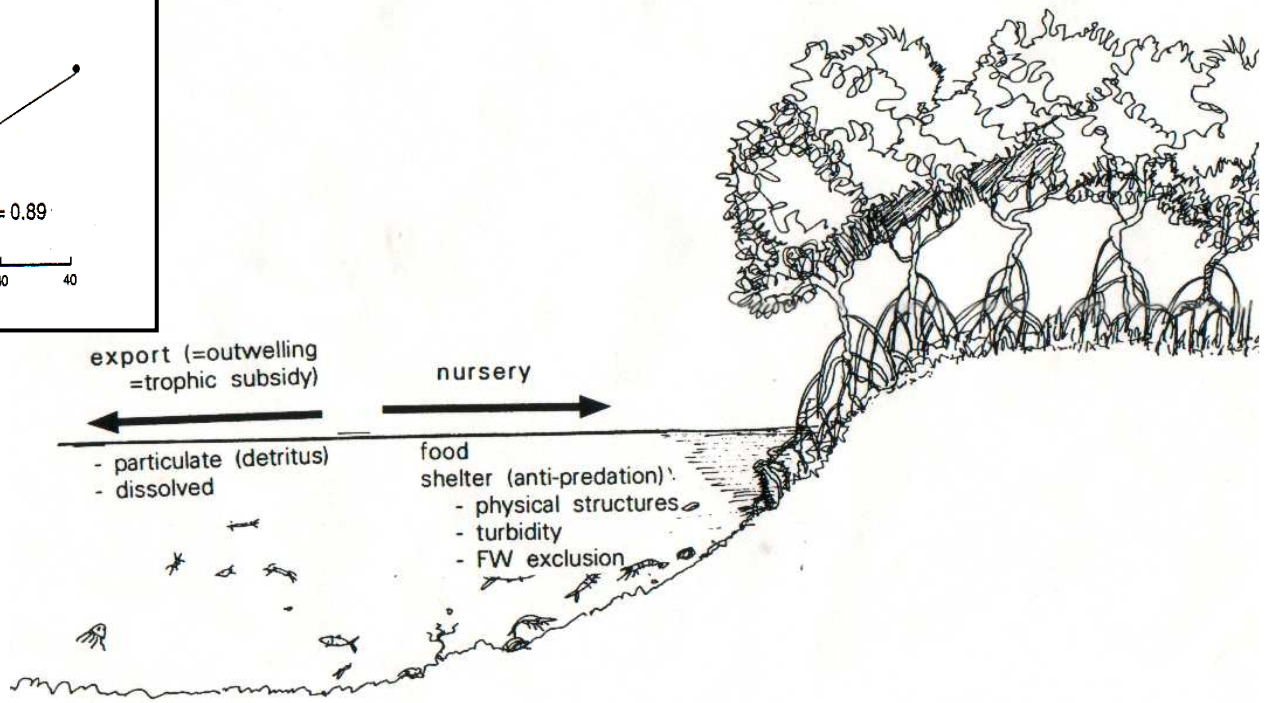
Photos from: Primavera JH, Sadaba RS, Lebata MJHL, Altamirano JP. 2004. *Handbook of Mangroves in the Philippines - Panay*. SEAFDEC/AQD and UNESCO.

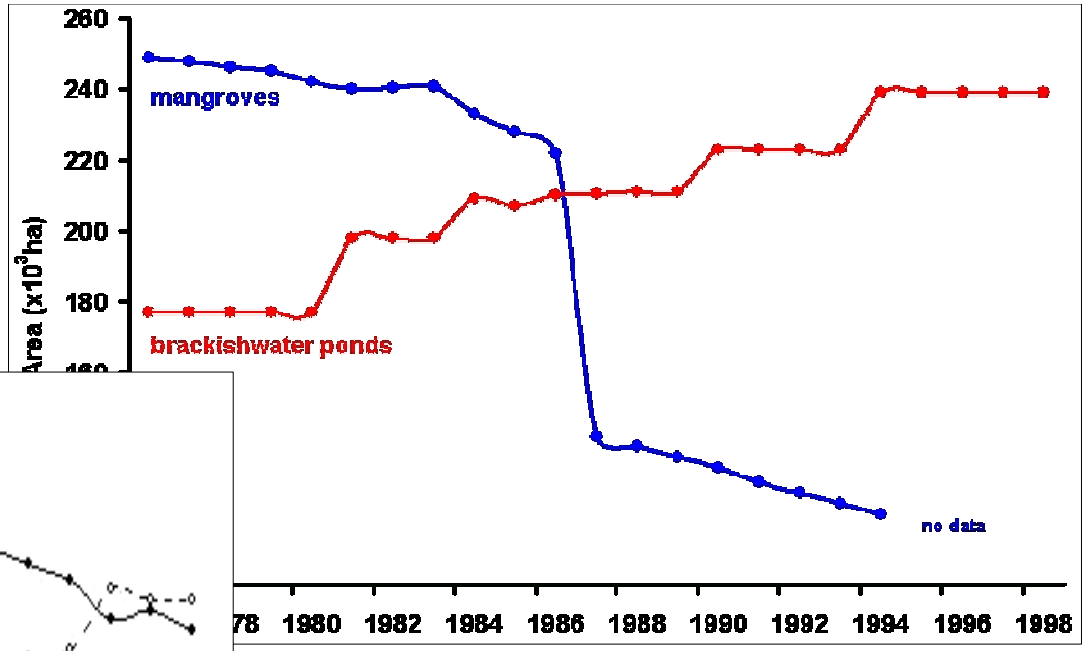


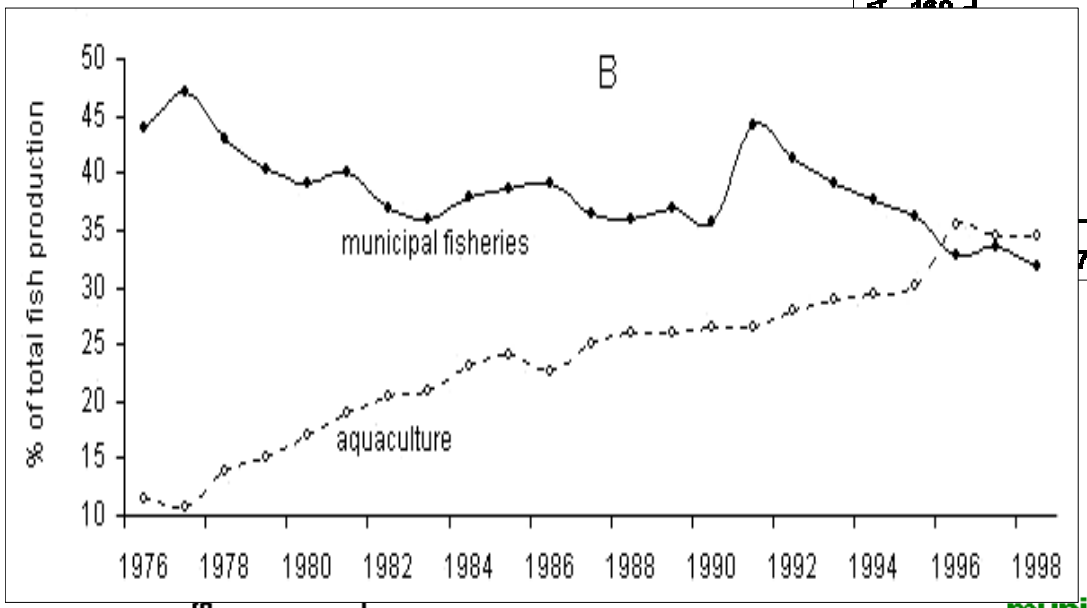


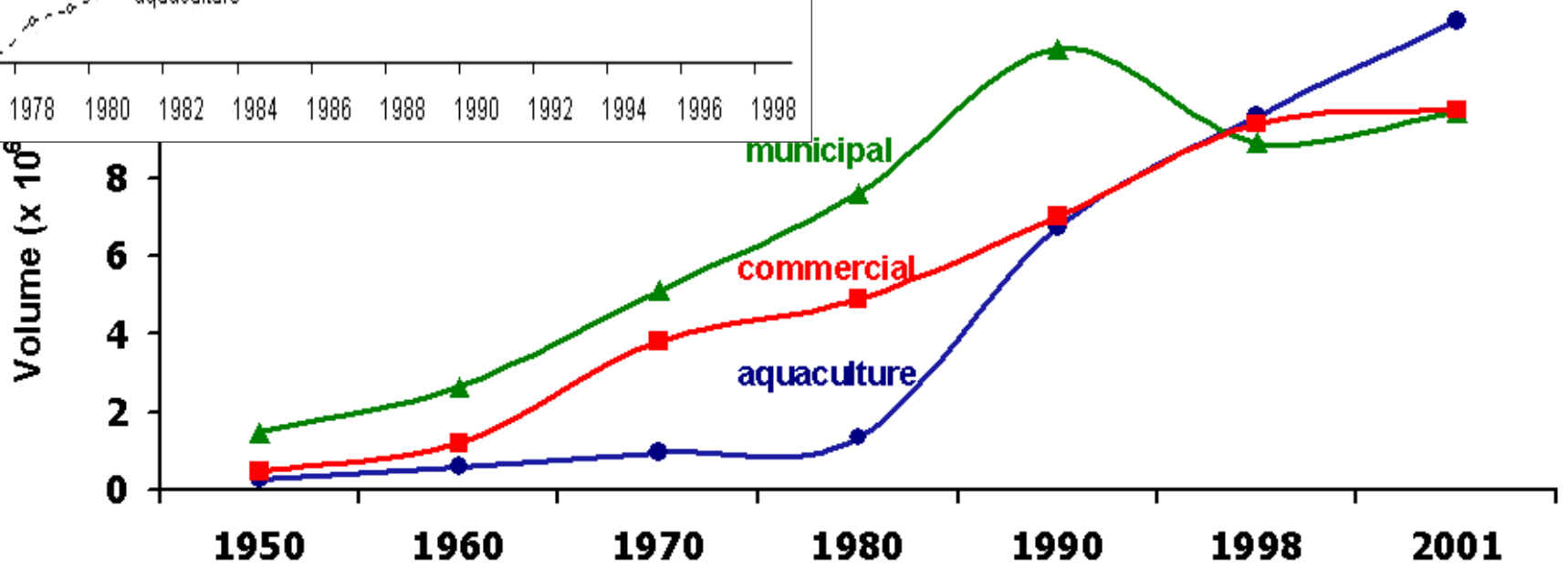


MANGROVE-FISHERIES CONNECTION




260
240
220
200
180
mangroves
brackishwater ponds
no data
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998


B
% of total fish production
50
45
40
35
30
25
20
15
10
municipal fisheries
aquaculture
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998


Volume (x 10
8
6
4
2
0
municipal
commercial
aquaculture
1950
1960
1970
1980
1990
1998
2001

Integrated Mangrove – Aquaculture Systems in Asia

J.H. Primavera, *Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Philippines*

SUMMARY

1) Technology: traditional – *gei wai, tambak*
state-driven – silvofisheries, shrimp-mangrove (land conflict), aquasilviculture, crab pens (fish production, income, conservation)

2) Systems: pond – mixed or separate
pen (mudcrab: most lucrative)

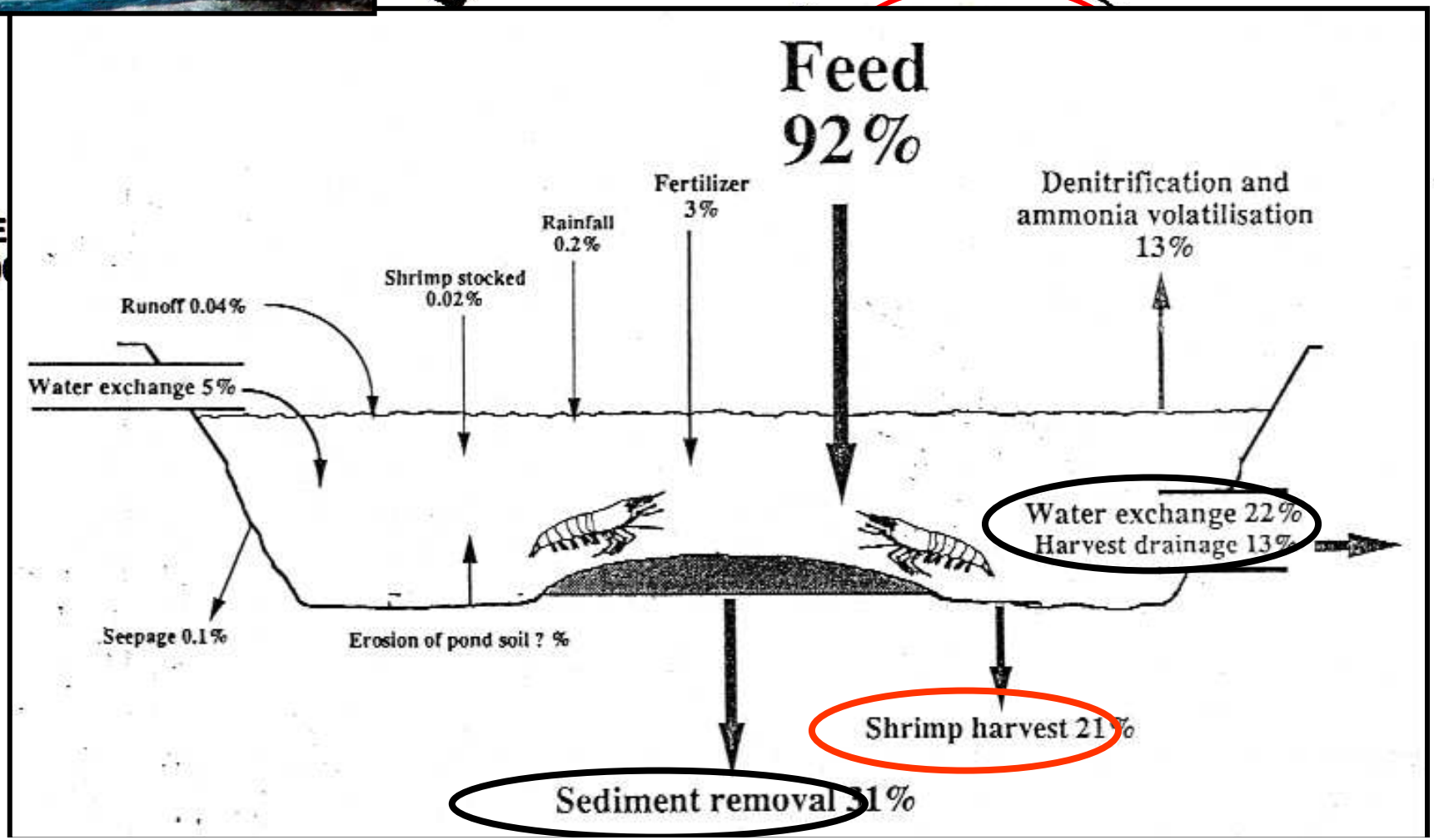
3) Aquaculture: species – fish, shrimp, crab
seed – tidal vs stocked
feed – natural vs supplementary
production - <500 kg/ha/yr (extensive)

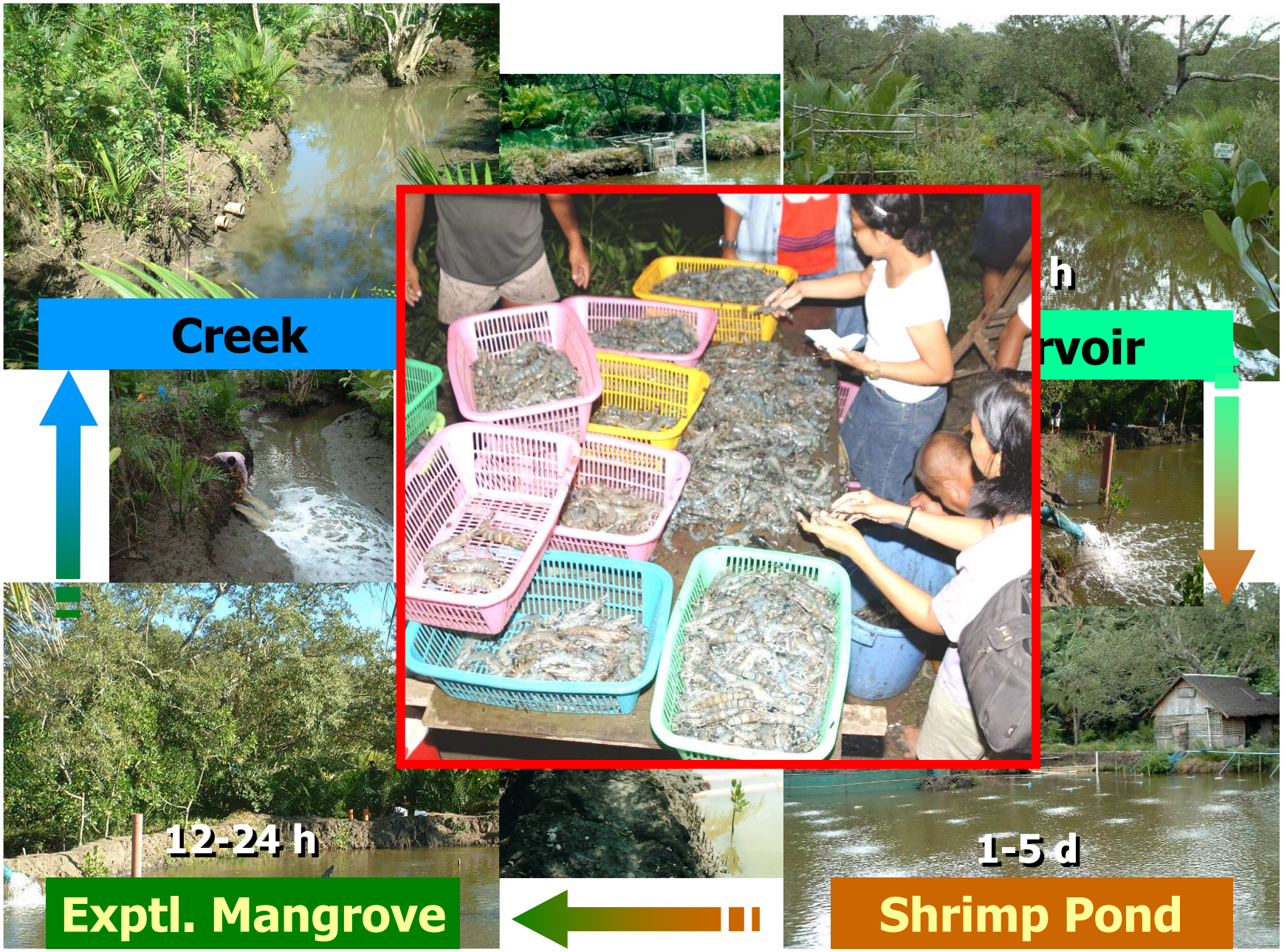
4) Mangroves: natural vs planted
Rhizophora vs *Avicennia*/others

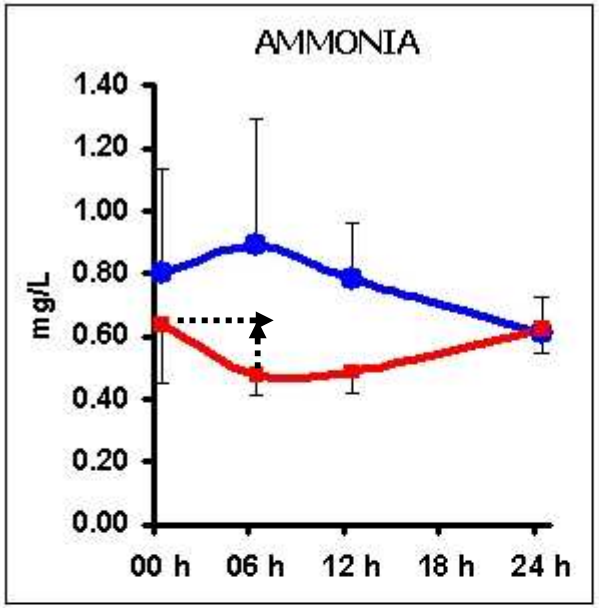
5) Flora/fauna diversity: lower in MFA ponds

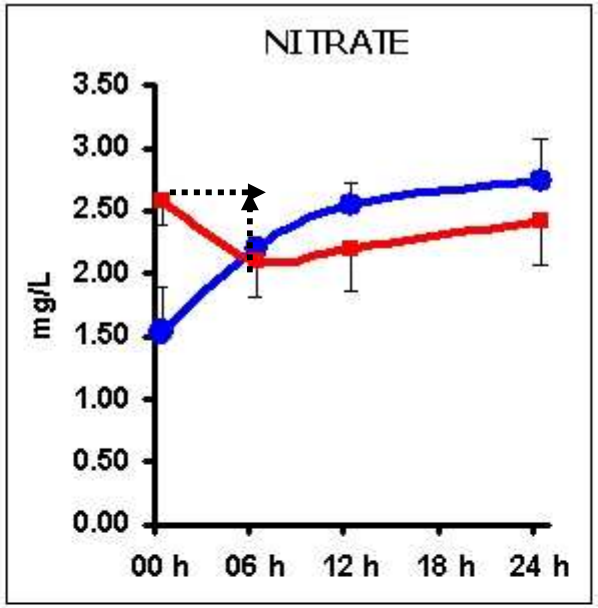
6) Problems/R&D: mangrove/aquaculture species, pond design, mangrove:pond ratio, raw fish substitutes

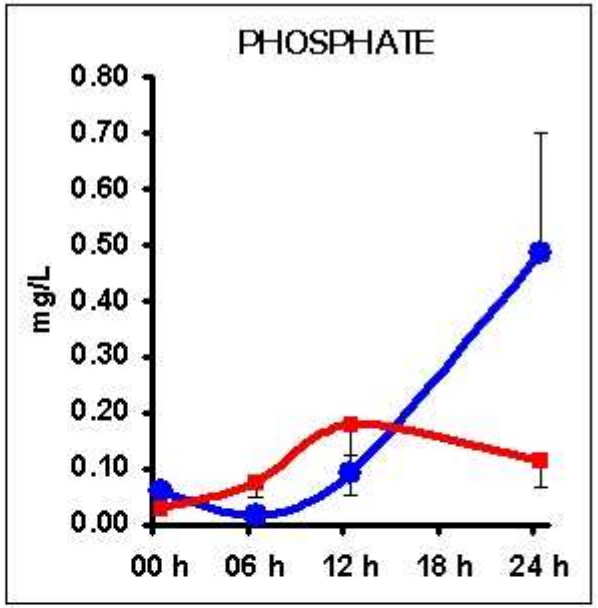
N budget: intensive shrimp pond (Briggs & Funge-Smith, 1994)

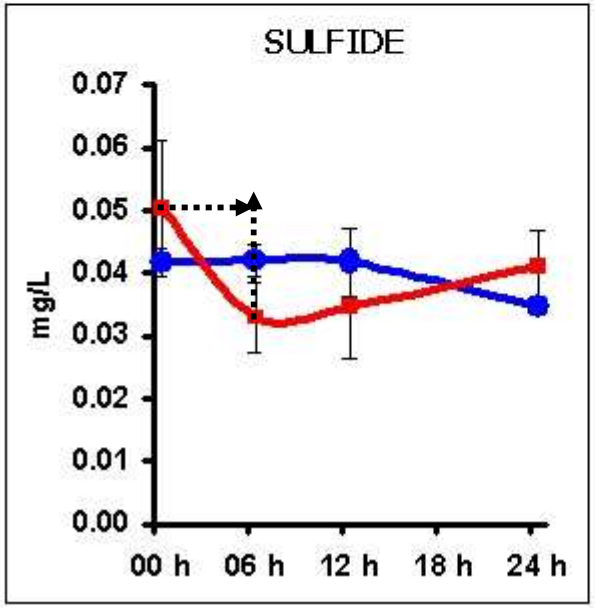


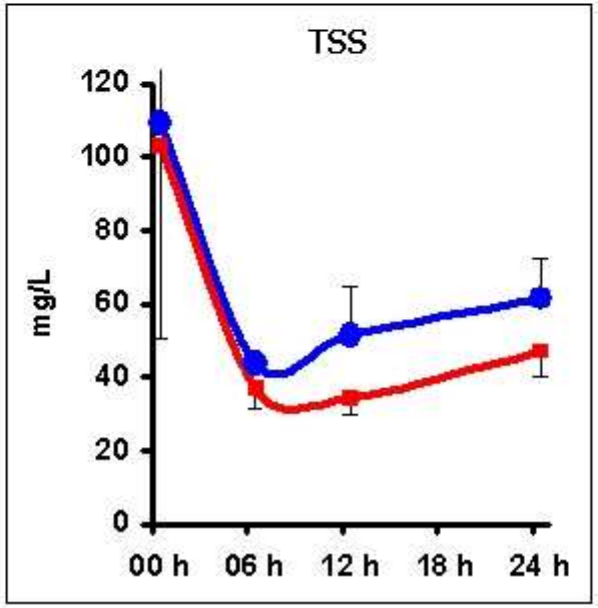

Creek
h
rvoir
12-24 h
Exptl. Mangrove
1-5 d
Shrimp Pond











Night cycle

Day cycle

Nutrients in effluents drained into natural mangrove stand

N removal from (SP) effluents drained into Impounded Mangrove

Rate × water vol. (see Table 2; 1 d = 6 h)

NH_3-N: mg/L/d		Vol (L)		
Rep 1	0.080	× 70,400	=	5,632.000
Rep 2	0.237	× 35,200	=	8,330.667
Mean	**0.158**			**6,981.333 mg NH_3-N/d**

NO_3-N: mg/L/d		Vol (L)		
Rep 1	0.733	× 70,400	=	51,626.667
Rep 2	0.233	× 35,200	=	8213.333
Mean	**0.483**			**29,920.333 mg NO_3- N/d**

Total N removal

6981.333 mg NH_3-N/d
+ 29920.000 mg NO_3-N/d
36,901.333 mg tot. N/d

36901.333 mg tot. N/d
÷ 320 m^2 Impounded Mangrove
115.317 mg tot. N/m^2 mng/d

N removal from Shrimp Pond effluents by Mangrove

Rate × water vol. **0.158** NH3-N mg/L/d = 6,981 mg NH3-N/d
(1 d = 6 h) 0.483 NO3-N mg/L/d = 29,920 mg NO3- N/d
Impounded Mangrove (area) 36,902 mg tot. N/d ÷ 320 m2
= **115.3 mg tot. N/m2 mng/d**

35% pond N loss thru water ex (Briggs & F.S./94)

$$\frac{\textbf{115.3 mg N/m}^2\textbf{ mng/d}}{\textbf{0.35 N loss}} = \textbf{329 mg (0.329 g) tot. pond N/m}^2\textbf{ mng/d}$$

60 g (6%) N kg^{-1} feed (I. Borlongan, pers. com)

$$\frac{\textbf{0.329 g tot. N/m}^2\textbf{ mng/d}}{\textbf{60 g N/kg feed}} = 0.0055 \text{ kg feed/m}^2 \text{ mng/d}$$

55 kg feed/ha mng/d

4% shrimp biomass feed rate

$$\frac{55 \text{ kg feed/ha mng/d}}{0.04 \text{ kg feed/kg shrimp/d}} = \textbf{1,375 kg shrimp/ha mng}$$

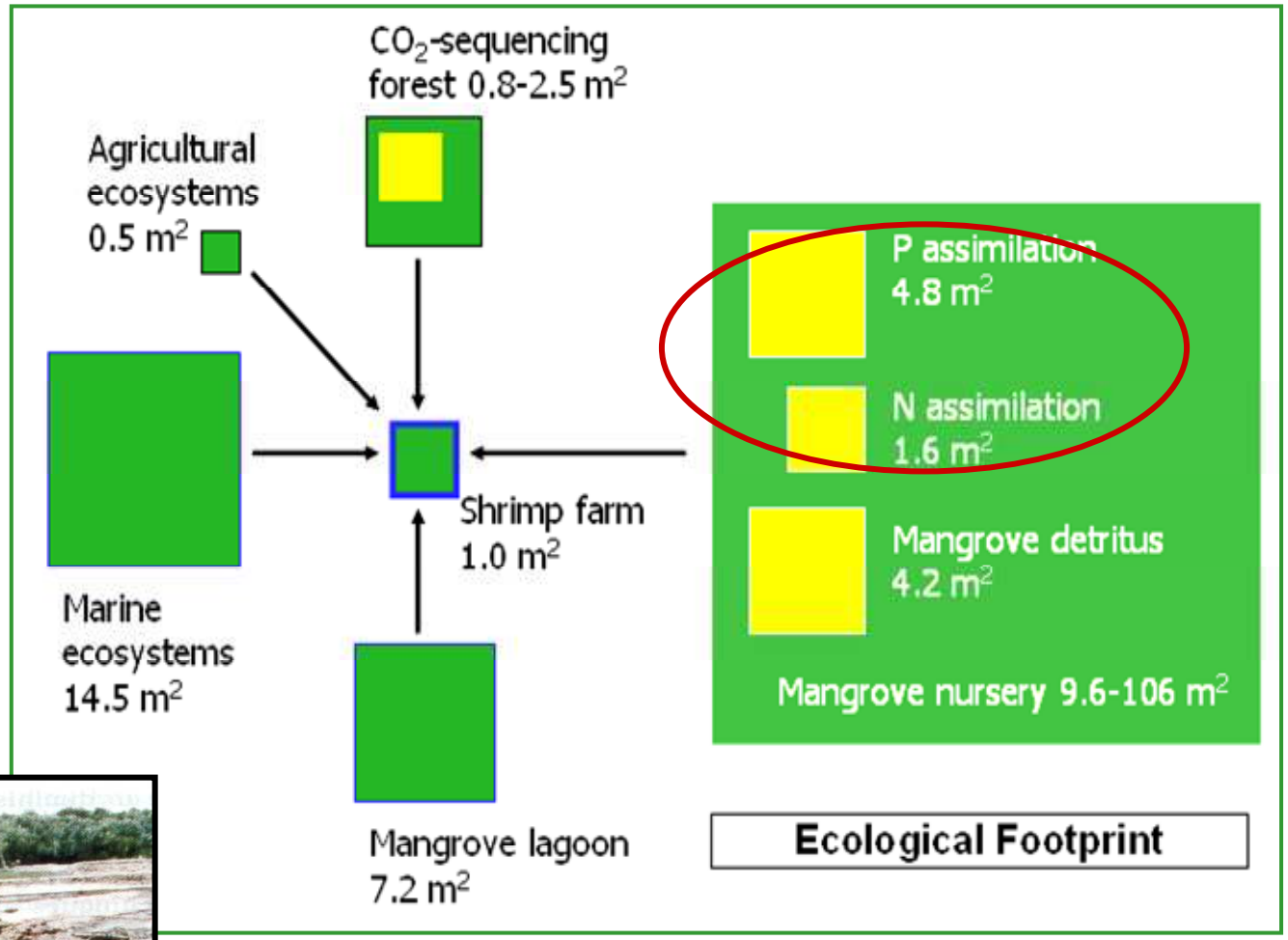
ABW = 1,375 kg @ 20 g = 68,750 pcs/ha
(harvest) @ 30 g = 45,833 pcs/ha

S.D. (m^2)	ha mng: per ha pond
10	1.45 – 2.18
30	4.36 – 6.54

Mangrove: Shrimp Pond area ratios for nutrient removal in pond effluents

Reference	System	Mangrove: Pond Ratio (area)	
		N	P
Boonsong & Eiumnoh,1995	Intensive	8.96	7.82
Robertson & Phillips, 1995	Intensive	7.21	21.7
	Semi-int.	2.4	2.8
Kautsky et al., 1997	Semi-int.	6.4	6.4
This study	Intensive	2.9-6.5	
	Semi-int.	1.4-2.2	

Ecological Footprint (Kautsky et al, 1997)



BULLETIN OF MARINE SCIENCE, 80(3): 795–804, 2007

MANGROVES AND SHRIMP POND CULTURE EFFLUENTS IN AKLAN, PANAY IS., CENTRAL PHILIPPINES

J. H. Primavera, J. P. Altamirano, M. J. H. L. Lebata, A. A. delos Reyes Jr., and C. L. Pitogo

Summary & Conclusions

- passing pond effluents through mangroves reduced nutrient levels (in day but not night)
- reduced nutrients due to biol. transformation (plant uptake, denitrif.), rather than physical dilution (nighttime increases) or tidal flushing
- nutrient removal function of mangroves supports **paradigm shift for aquaculture to clean up effluents before release**
- **mangrove: pond ratio for effluent processing: 2-9:1 for N, 2-22:1 for P**
- implications for Philippines: compliance with national laws: **greenbelt (20-, 50- and 100-m) and mangrove rehabilitation of abandoned ponds**
- need to **reverse present 0.5 ha mangrove: 1 ha pond** ratio in the Philippines

Mudcrab Culture in Mangrove Pens

Cost and return analysis for 1000 m^2 mud crab *Scylla serrata* pens using two feeding treatments.

Production data	Fish Biomass	Pellets + Fish Biomass
Survival rate (Table 5)	40.4%[	37.2%
Corresponding body weight (Table 5)	211 g	252 g
Production: 1 crop 2 crops	74 kg 148 kg	82 kg 164 kg
Item	**Total Value (PhP)[a]**	**Total Value (PhP)[a]**
Revenue	22,205.45	24,467.18
Non-cash costs: Depreciation	1,975.00	1,975.00
Caretaker's salary	1,5,00.00	1,500.00
Sub-total	3,475.00	3,475.00
Total operating cost run^{-1}	23,171.01	24,425.23
Net cash return $crop^{-1}$	2,509.44	3,516.95
Net cash return yr^{-1} (2 crops)	5,018.88	7,033.89
Net returns $crop^{-1}$	Negative	41.95
Net return yr^{-1} (2 crops)	Negative	83.90
Return on investment	**27.5%**	**38.5 %**
Payback period (years)	**3.6**	**2.6**

Impacts of crab pen culture on mangrove community structure in Zarraga, Aklan, central Philippines.

		Pens			Control
		May 2002	Jan 2004	% change	Jan 2004
Stems/ha	Seedlings	4,984	9,850	97.6	90,833
	Saplings	3,216	5,003	39.9	12,533
	Trees	1,167	1,600	37.1	1,267
	Total	9,368	**15,950**	70.3	**104,633**
Basal area (m^2 per ha)	Seedlings	0.10	0.19	90.0	1.8
	Saplings	1.01	1.41	39.6	3.9
	Trees	5.96	6.45	8.2	7.8
	Total	**7.07**	**8.05**	13.9	**13.5**
Shannon Index of Sp. Diversity		**0.52**	**0.45**		**0.59**

Conclusions

- Incomplete, low-cost pellets **can replace fish requirement** in mud crab diets
- Economic analysis showed **viability of crab culture in mangrove pens** using fish biomass + pellets to reduce requirement for (low-value) fish, a food item of poor coastal communities
- Presence of crabs results in fewer mangrove seedlings and saplings, but **did not affect trees**

Integrated production systems

- polyculture
- aqua-agriculture
- aqua-silviculture

Code of Practice for Sustainable Use of Mangrove Ecosystems for Aquaculture in Southeast Asia

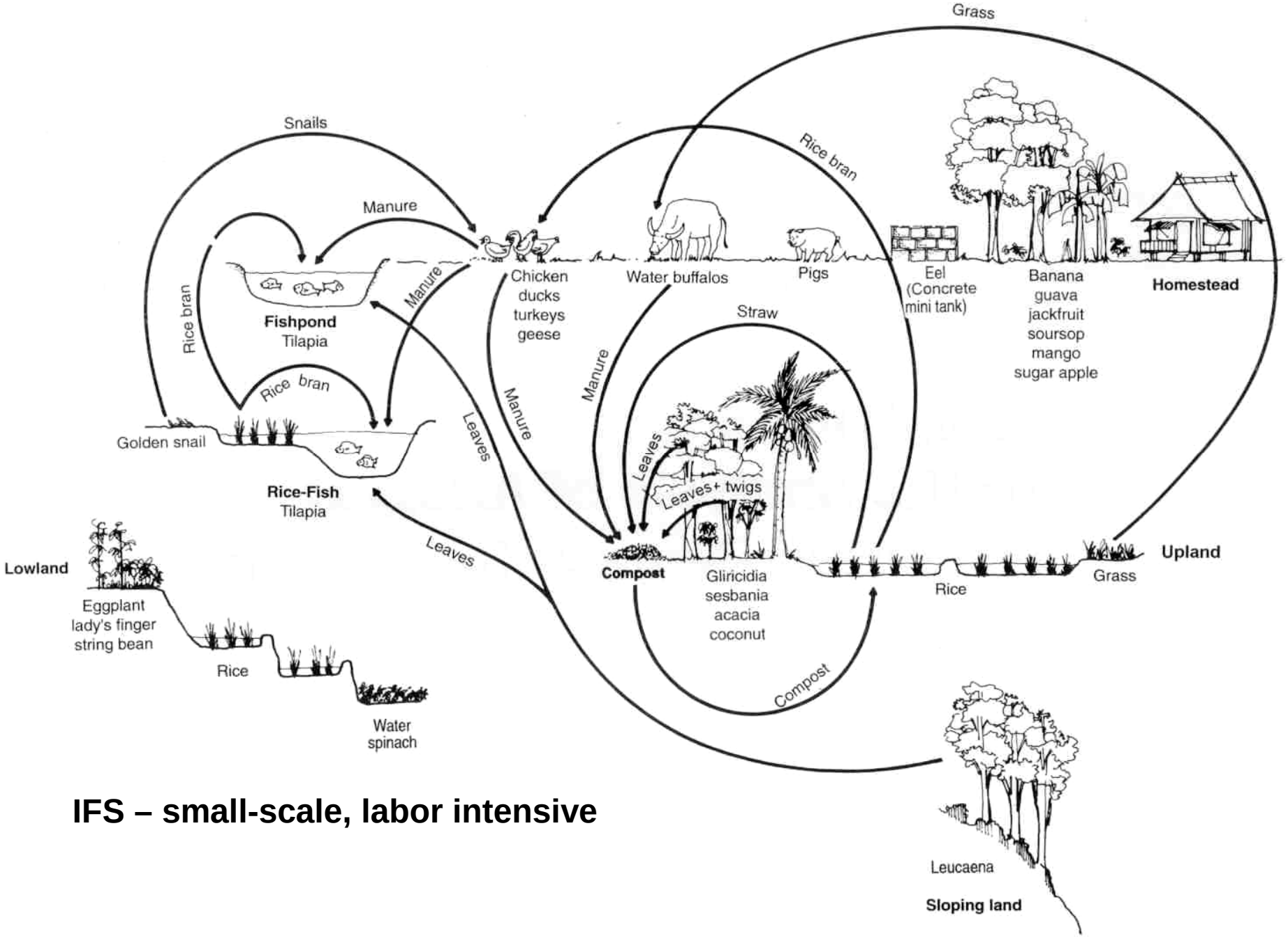
Mangrove-Friendly Aquaculture Program

Government of Japan Trust Fund

Aquaculture Department

Southeast Asian Fisheries Development Center

August 2005



IFS – small-scale, labor intensive

Mangrove conservation in Iloilo and Aklan provinces thru --

- *education*
- *local governance*

PEW FELLOWS PROGRAM
IN MARINE CONSERVATION

Mangrove Instructional Materials Production for Elementary Level

Module Writers - Purita P. Bilbao, Crisanto Lopez, Jr.,
Ruth L. Gelvezon, Marievic M. Violeta

Module 1. Starting a Walk to the Mangroves

Module 2. Mangroves: Forests Growing by the Sea

Module 3. Mangroves: Take a Closer Look

Module 4. Mangroves: Our Natural Treasure

- Traditional uses (Forestry/ Fishery Products)
- Services
- Ecological Benefits
- Social Benefits
- Values Derived
- Medicine
- Wildlife Habitat