MOVING FORWARD TO THE FUTURE: BIOECONOMIC MODELLING OF FISHERY CONSERVATION POLICIES IN THE PHILIPPINES

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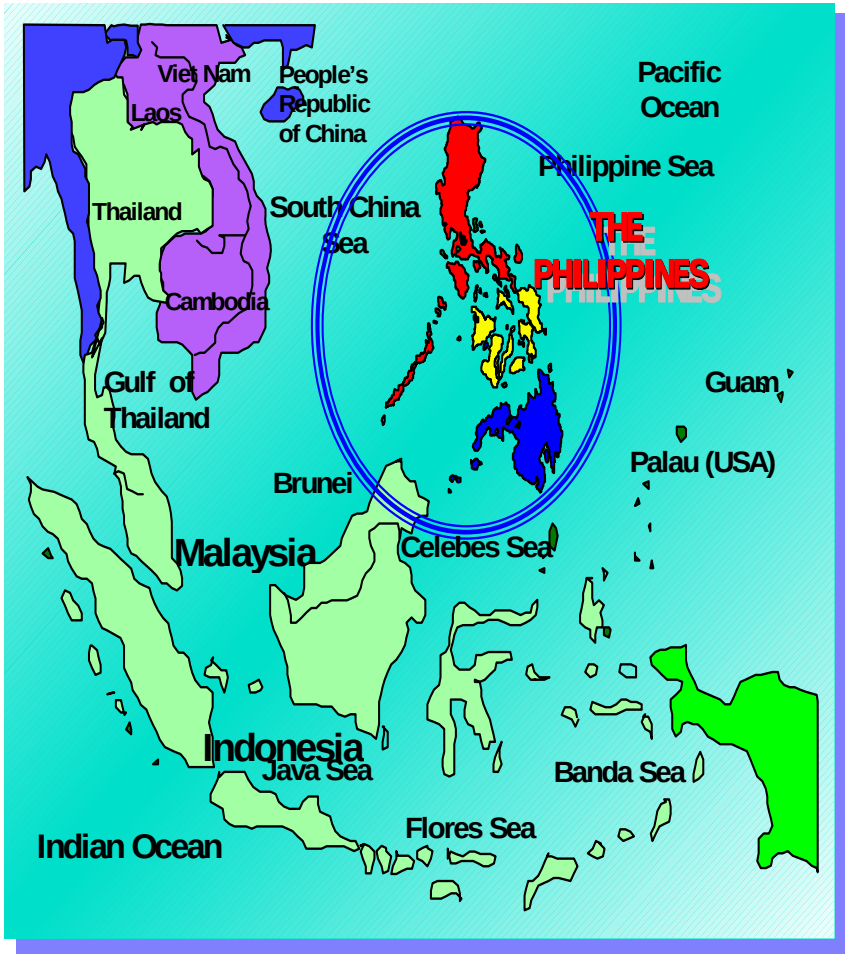
Why overfished or depleted?

- Open access nature of fishing (lack of management, regulation, enforcement)
- Widespread technological advances (more efficient gear, stronger and larger nets, electronic fishing devices, increased ability to fish all over the world, even in the most isolated places
- Economic development policies of governments, esp those providing subsidies to keep inefficient boats running and encouraging even more investment in fishing
- Growing human population
- Large increase in prices for a growing global market

NATIONAL STATISTICS



- ***Twelfth largest fish producer,1998 (1.8 M mt)***
- ***Eighteenth aquaculture producer (135 mt)***
- ***Since 1991, fish catch declined at about 5.4 % yearly***
- ***2.34 % population growth rate***

PHILIPPINE SITUATION

- Direct income to 1.3 M fishers and their families
- Ave earning of EUROS 56 per month or over EUROS 875 M worth of employment annually

Lamon Bay Statistics

- ***Fifth highest commercial fishing ground***
- ***Ninth highest municipal fishing ground***
- ***Since 1985, fish catch declined at about 13.5 % yearly (> 5.4 % national average)***
- ***3.62 % population growth rate***

RESEARCH PROBLEM

What are the reasons for policy failure in Lamon Bay?

- **No study to determine effectiveness, acceptability and efficiency of policies**

POLICY RELEVANCE

- ***Republic Act 8550***
  - **justifies banning of commercial gears in municipal waters**
  - **extends municipal waters from 7 to 15 km from coastline**
- ***DA Administrative Order No. 4 (1996)***
  - **prohibits use of superlight or halogen lights**
- ***Regulation of fish cages***
  - **Illegal structures affecting small fishermen by reducing their fish catch and income**
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These structures destroy the breeding grounds of milkfish which also serve as sanctuary for milkfish fry in times of bad weather

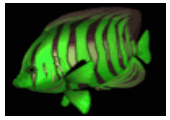
POLICY RELEVANCE

- ***Ban on electric shiners***
  - **These are fishing boats equipped with 200 to 1,000 watts incandescent lights powered by a dynamo**
  - **Prohibited in municipal waters because the light also attracts smaller fish that are not yet harvestable**
  - **Allowed if for research purposes only**

BASIS FOR POLICY SELECTION

- ***Potential to provide municipal and small-scale fishermen a wider area within which to operate fishing boats of 3 gross tons or less and consequently increase their catch***

General Objective



To use economic evaluation in assessing the fisheries policies that can be implemented in Lamon Bay

Specific Objectives

- ***To evaluate some of the existing fisheries policies;***
- ***To assess the changes in benefits and costs of municipal fishermen using different fisheries policies;***
- ***To evaluate the changes in fishery resource quality of the area using different fisheries policies;***
- ***To determine the major factors that influence trends in fishery catch under different fisheries policies, using a bioeconomic model; and***
- ***To recommend further enhancements, where necessary, to the fisheries policies.***

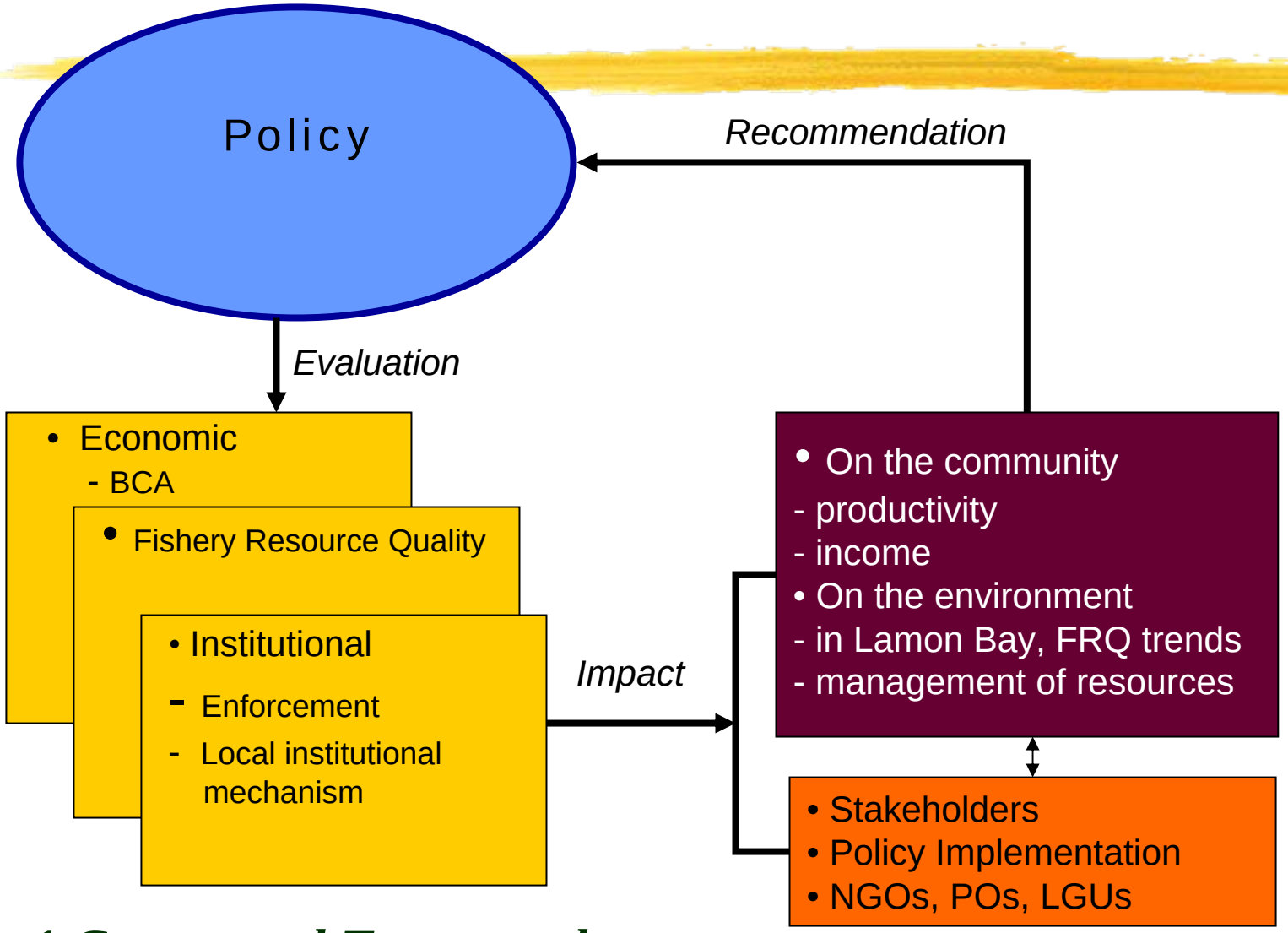
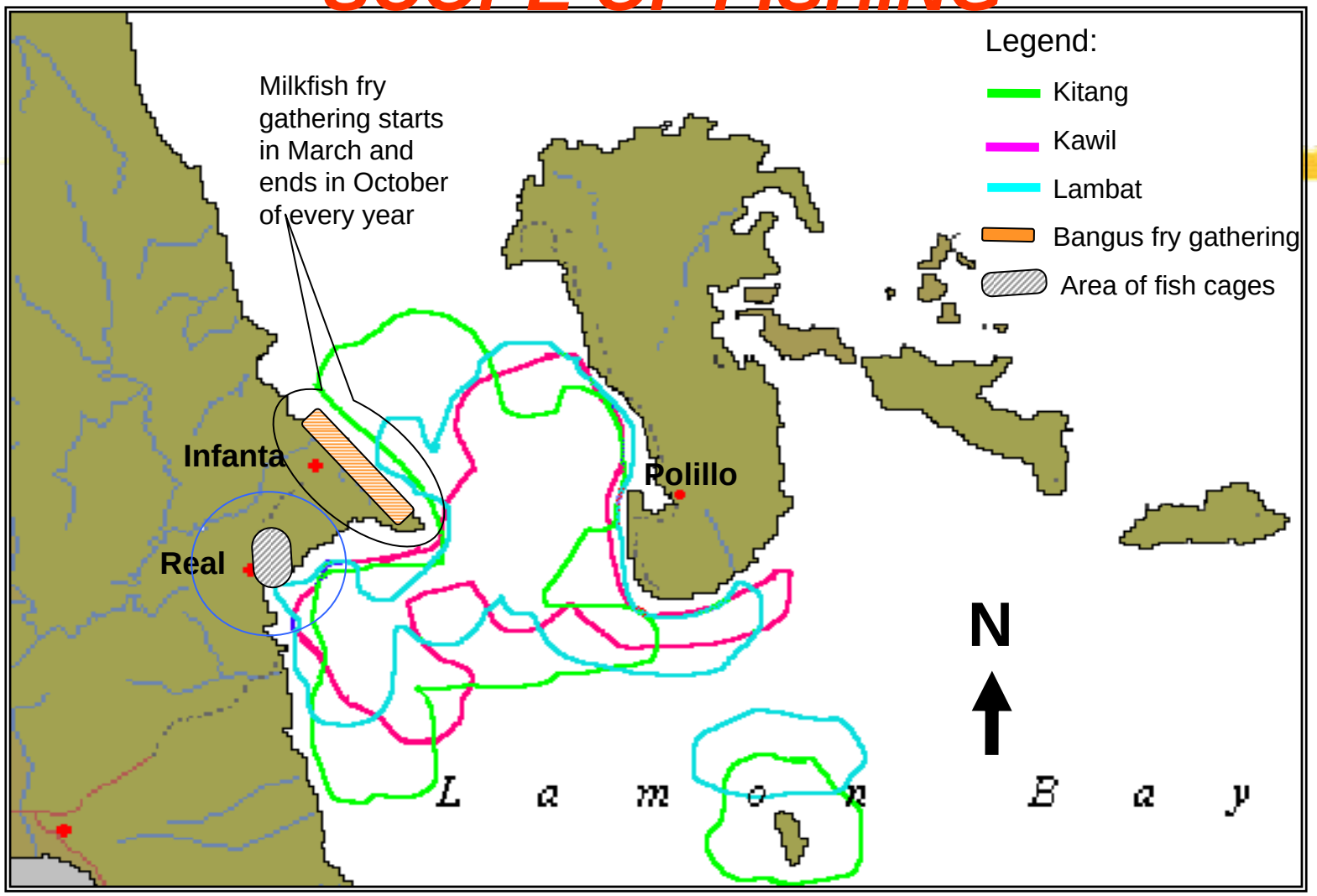


Fig.1 Conceptual Framework

METHODOLOGY

- ***scope of fishing***
- ***identified 3 fishing methods used: hook and line, multiple hooks, and gill net (fish catch, length and exploitation rates, CPUE)***
- ***investigated current fisheries policies (effectivity and efficiency)***
- ***survey of 450 fisherfolk***
- ***interview of local leaders and stakeholders***
- ***bioeconomic modelling***
- ***Benefit Cost Analysis***

SCOPE OF FISHING



Number and type of municipal fishing gear by municipality, Lamon Bay

FISHING GEAR	MUNICIPALITY			
	Infanta	**Real**	**Polillo**	**TOTAL**
Hook and line (kawil)	**108**	**255**	**233**	**596**
Multiple hook (kitang)	**52**	**78**	**15**	**145**
Gill net (lambat)	**13**	**31**	**91**	**131**
Others	**2**	**50***	**20**	**72**
ALL	**175**	**414**	**359**	**948**

*Light-light (patungkab) – used for catching squid,crab

Length and exploitation rates of common fish species in Lamon Bay

SPECIES	LENGTH (cm)	EXPLOITATION RATE (per year)
Nemyptherus bathybus	**24.4**	**.71**
Sardinella spp.	**7.9**	**.42**
Selar crumenopthalmus	**10.1**	**.78**
Caranx sexfaciatus	**25.6**	**.58**
Spyraena spp.	**99.0**	**.65**
Rastrelliger kanagurta	**24.5**	**.70**
Parupeneus spp.	**10.2**	**.61**
Ephinephilus spp.	**31.2**	**.75**
Lethrinus spp.	**24.7**	**.72**

SPECIES/LOCALITY	LENGTH (cm)	EXPLOITATION RATE (per year)
Nemyptherus bathybus		
Camotes Sea	25.6	.54
Moro Gulf	30.0	.59
Tayabas Bay	35.0	.76
Guimaras Strait	31.0	.60
Manila Bay	29.9	.54
Lamon Bay	24.4	.71
Sardinella spp.		
Visayan Sea	13.9	.69
Tayabas Bay	13.5	.64
Samar Sea	13.6	.66
Ragay Gulf	8.2	.33
Lamon Bay	7.9	.42
Selar crumenopthalmus		.61
Camotes Sea	12.9	.31
Visayan Sea	10.2	.46
Moro Gulf	11.8	.36
Samar Sea	11.5	.74
Ragay Gulf	12.1	.78
Lamon Bay	10.1	
Caranx sexfaciatus		.38
Samar Sea	30.2	.55
Burias Pass	28.0	.45
Ragay Gulf	27.0	.53
Manila Bay	25.7	.58
Lamon Bay	25.6	

Volume of fish catch, relative abundance and CPUE by municipal fishing gear and by species, Lamon Bay.

FISHING GEAR	SPECIES	VOLUME OF CATCH (kg)	RELATIVE ABUNDANCE (percent)	CPUE (kg/hr)
Hook and Line	***Sardinella spp.***	58,296.25	21.74	
	Selar crumenopthalmus	38,233.40	14.26	
	Nemyptherus bathybus	31,066.50	11.59	
	Caranx sexfaciatus	24,547.75	9.15	
	Spyraena spp.	16,740.15	6.24	
	Rastrelliger kanagurta	11,085.60	4.13	
	Parupeneus spp.	10,720.55	4.00	
	Ephinephilus spp.	8,008.75	2.99	
	Lethrinus harak	7,368.05	2.75	
	Anampses caeruleopunctatus	6,362.30	2.37	
	Lutjanus fulvus	5,565.15	2.08	
	Priacanthus spp.	4,350.80	1.62	
	Others	45,810.05	17.08	
	Total	**215,685.30**	100.00	**2.27**

FISHING GEAR	SPECIES	VOLUME OF CATCH (kg)	RELATIVE ABUNDANCE (percent)	CPUE (kg/hr)
Multiple hook	*Nemyptherus bathybus*	40,888.19	43.47	
	Auxis thazard	9,568.19	10.17	
	Priacanthus spp.	8,297.63	8.82	
	Lutjanus fulvus	6,700.81	7.12	
	Caranx sexfaciatus	6,361.88	6.76	
	Lethrinus harak	4,433.38	4.71	
	Thunnus albacares	3,655.81	3.89	
	Lethrinus harak	2,818.44	3.00	
	Parupeneus spp.	2,561.06	2.72	
	Decaptherus spp.	1,205.31	1.28	
	Others	7,576.25	8.05	
	Total	**94,066.95**	100.00	**0.96**

FISHING GEAR	SPECIES	VOLUME OF CATCH (kg)	RELATIVE ABUNDANCE (percent)	CPUE (kg/hr)
Gill net	*Sardinella spp.*	10,828.69	18.14	
	Stolephorus spp.	7,846.88	13.15	
	Parupeneus spp.	4,924.13	8.25	
	Spyraena spp.	4,770.56	7.99	
	Caranx sexfaciatus	3,673.69	6.16	
	Leio equulus	3,594.38	6.02	
	Nucus (squid)	2,975.06	4.98	
	Siganus caniculatus	2,404.69	4.03	
	Megalaspis cordyla	2,387.81	4.00	
	Ablennes hians	2,342.25	3.92	
	Rastrelliger kanagurta	2,276.44	3.81	
	Scarus spp.	1,336.5	2.24	
	Others	10,324.13	17.3	
	Total	**59,685.21**	100.00	**9.52**
	ALL	**369,437.46**		

Figure 4.2. Average volume of catch from hook and line by fish species, Lamon Bay.

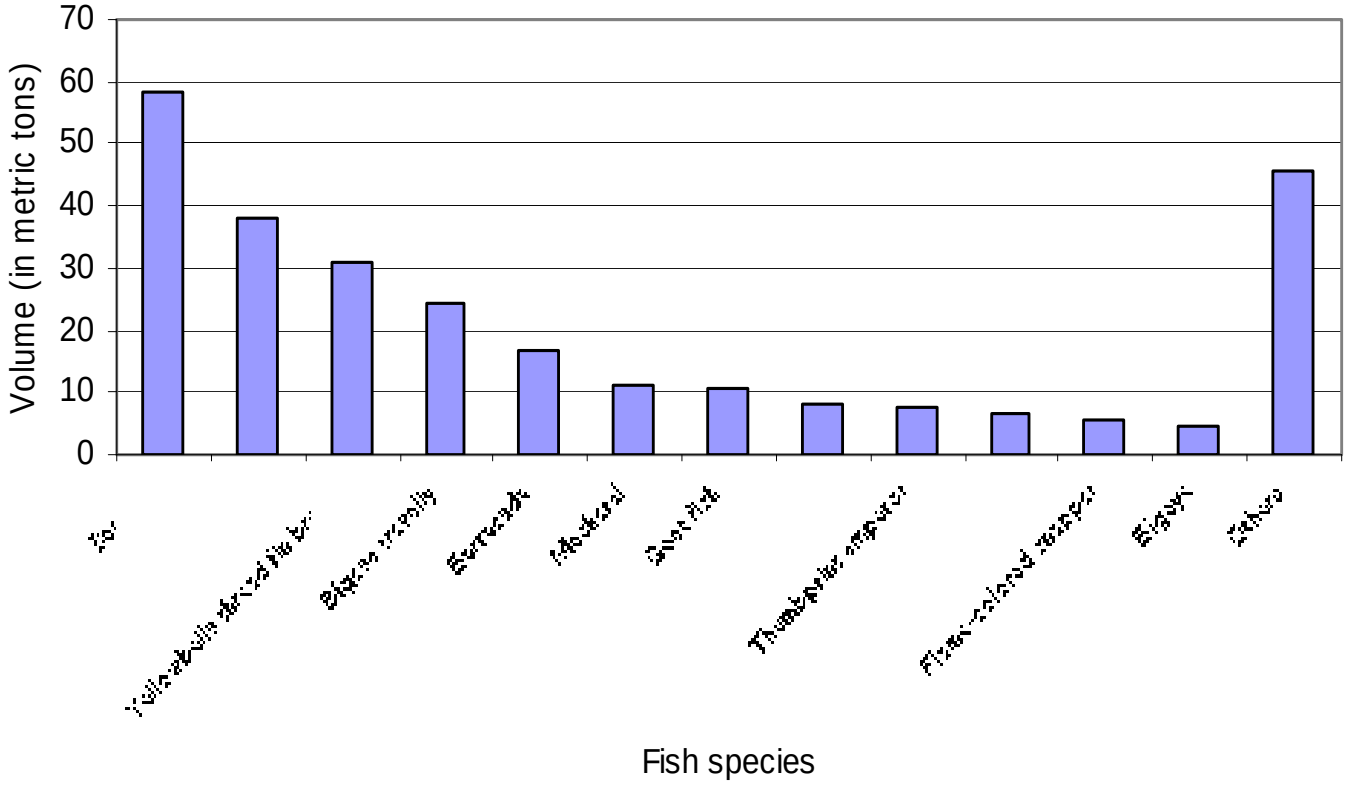
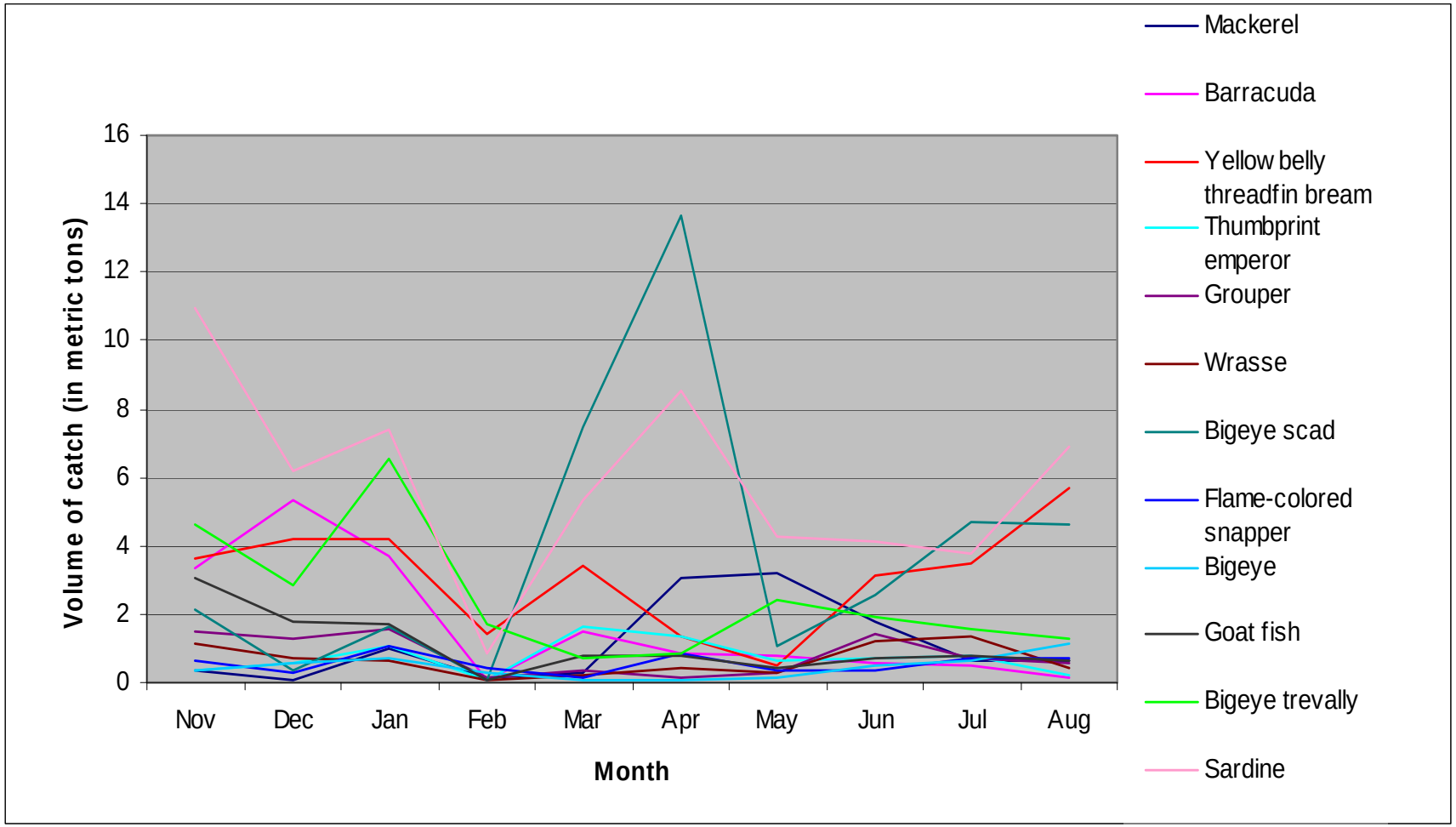


Figure 4.3. Average monthly fish catch from hook and line, Lamon Bay.



AVERAGE PRODUCTIVITY

- Declining
- BFAR statistics show that average productivity per gill net was 52 kg. in 1965.
- 1975, these figure dropped to 19 kg,
- This study revealed that at present the average productivity per boat during the 10-month monitoring is 4.48 kg.
- This shows that the average productivity per boat (gill net) had been declining through the years.

Effectivity of policies?

- ***most people surveyed felt that existing policies were slightly effective***
- ***exceptions were those relating to sanctuaries, permits & licenses which were perceived as ineffective***
- ***84 % respondents operating without fishing licenses***
- ***After assessing the declining productivity and resource quality data***
- ***Therefore, policy failure***

Major Problems in Policy Implementation and Suggestions for Improvement (Survey)

- **Lack of will to implement**
  - **full implementation of the law**
  - **sincerity of police officers and gov't officials**
- **Inefficient monitoring**
  - **regular monitoring**
  - **full implementation of the law**

Why were policies failing?

- **Many policies were not supported by fishing communities**
- **People could not appreciate the relevance to the problems of their everyday life**
- **Local institutions were constrained by lack of funds, political will and technical know-how**
- **This led to poor policing and enforcement.**
- **Significance of poor policy implementation was backed up by further analysis thru bioeconomic modelling and benefit cost analysis**

BIOECONOMIC MODEL

The biological unit consists of a growth function relating natural growth (reproduction plus individual growth minus mortality) to the fish population size or fish stock. Such relationship is the logistic biological growth function:

$$G = G(X);\ G(X) >/< 0 \text{ for } X >/< K,\ \partial G/\partial X >/< 0 \quad \text{(Eq. 1)}$$

For X >/< maximum sustainable yield, $^2\partial G/\partial X^2 < 0$ throughout

Where G is natural growth measured in weight of biomass

X is fish stock also measured in weight of biomass

K is natural equilibrium stock or carrying capacity of the environment

BIOECONOMIC MODEL

The economic unit consists of the relationship between output (catch) and inputs (fishing effort) known as the production function:

$$Y = j(E);\ \partial / \partial E > 0,\ \partial j / \partial E^2 < 0 \quad \text{for } X = \bar{x} \qquad \text{(Eq. 2)}$$

This equation implies that, for any given X, the larger the effort (E), the greater is the catch (Y). Conversely, for any given E, the larger the fish stock, the greater is the catch:

BIOECONOMIC MODEL

$Y = r(X)$; $\partial r/\partial X > 0$, $\partial^2 r/\partial X^2 < 0$, for $E = E$ (Eq. 3)

If we combine Eqs. (2) and (3), the fishery production function is:

$Y = F(E,X)$; $\partial F/\partial E > 0$, $\partial^2 F/\partial X^2 > 0$, $\partial F/\partial E < 0$, $\partial^2 F/\partial X^2 < 0$, (Eq. 4)

The fish stock (X) in the fishery production function (Eq.5) can be assumed to be constant ($X = X$) and eliminated from the equation as an explanatory factor of variations in catch, hence,

$Y = f(E,X)$

BIOECONOMIC MODEL
$Y = f(E, X)$

Where Y = production function

E = j (POP, FMEN, FTECH, PR)

X = fish stock

FMEN: MFGAT, ESHINER, FCAGE

FTECH: HNLINE, MHOOK, GNET

The hypothesized values of the partials are:

- ∂j / ∂POP > 0
- ∂j / ∂ FMEN >0
- ∂j / ∂FTECH > 0
- ∂j / ∂PR >0

Assessment of yield equations

Table 4.10. Results of log-linear model for fish catch of municipal fishing gears (low implementation of ban on electric shiners) Lamon Bay.

INDEPENDENT VARIABLE	DEPENDENT VARIABLE								
	QMACK	QBARRA	QYELLOW	QTHUMB	QGROUPER	QFCSNAPPER	QGOAT	QSARDINE	QTREV
Constant	82.67*** (10.26)	100.23** (6.25)	142.07*** (8.54)	165.76** (.75)	164.33** (.63)	145.74** (.242	134.23* (1.39)	122.34*** (2.23)	108.24** (.87)
POP	-3.54*** (8.45)	-4.35** (2.65)	-9.16*** (6.24)	-7.03** (5.33)	-5.94** (4.79)	-8.72** (3.05)	-6.37** (7.19)	-4.25** (3.73)	-6.18*** (248)
MFGAT	-.36** (3.78)	-.42* (1.37)	-.37* (1.33)	-.84** (2.17)	-.53* (4.85)	-.65* (3.17)	-.62* (1.89)	-.41* (3.47)	-.54** (2.05)
ESHINER	-.04* (1.62)	-.003* (.09)	-.002* (.99)	-.0058* (.25)	-.08* (.34)	-.97* (.38)	-.009* (.11)	-.009* (.39)	-.08* (.23)
FCAGE		-.008 (.32)	-.009 (.35)	-.006 (.23)	-.001 (.29)	-.006 (.22)	-.007 (.28)	-.005 (.28)	-.009 (.23)
HNLINE	-.44*** (3.34)	-.38*** (3.50)	-.12*** (2.01)	-.29*** (2.05)	-.39*** (3.04)	-.94*** (3.23)	-.23*** (2.24)	-.14*** (295)	-.29*** (2.49)
MHOOK			-.23*** (1.69)	-5.48*** (2.68)	-.13*** (2.19)	-.24*** (2.85)	-.02*** (3.10)		-.04*** (3.94)
GNET	-.12*** (3.65)	-.29*** (2.01)					-.19*** (3.02)	-.009 (.10)	-.29*** (2.12)
PMACK	.80** (4.82)								
PBARRA		.98** (8.81)							
PYELLOW			.83*** (4.66)						
PTHUMB				.75* (1.97)					
PGROUPER					.09* (1.49)				
PFCSNAPPER						.003** (2.54)			
PGOAT							.02** (4.98)		
PSARDINE								.06*** (3.27)	
PTREV									.04*** (2.28)
R^2	.923	.915	.947	.922	.947	.933	.927	.928	.929
F	25.64	24.39	38.74	23.09	48.70	38.99	51.55	41.48	23.78
PR>f	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001

Note: Figures in parentheses are F values
***, **, *= significant at 1 %, 5 % and 10% probability levels, respectively

RESULTS OF THE BIOECONOMIC MODEL

- R^2 are all significant and high, except for milk cages
- Combination of regulation of fish cages and banning of electric shiners show very high coefficient of determination, R^2 ranging from .829 to .952. The effect of fish cages is also insignificant

RESULTS OF THE BIOECONOMIC MODEL

- An increase in the level of fishing effort did not increase yield in all fishing gears but instead resulted in a decline in fish catch
- Marginal product is negative. An additional unit of fishing boat will decrease the fish catch of the rest
- Decreasing average fish catch per boat

Costs (in EUROS) of Implementation & NPV under different Policy Schemes, Lamon Bay

SCHEME	COST			NPV		
	Shiners	Fish cages	Comb	Shiners	Fish cages	Comb
No regulation (948 gears)	None			(.22 M)		
monitoring/implementation	30,000			(.16M)	(.21 M)	(.16 M)
High (No. of fishers not limited)	614,500			.02 M	.003 M	.03 M
High (Limit no. of fishers)	614,500			.03 M	.01 M	.04 M

POLICY IMPLICATIONS

- **Current regulations to deal with overfishing are neither cost effective nor address the underlying problems of overexploitation of fish stocks and open access to fishing areas**
- **A tradable quota system may provide an answer to the problem**
- **Total Allowable Catch is stipulated in the New Fisheries Code (not yet implemented)**

RECOMMENDATIONS

- **Initial reductions could be made by revoking the permits of fishermen who contravene fishing regulations e.g. regarding permissible catch size or seasons**
- **To allow flexibility, the allocated quotas might be tradable**
- **This will allow new fishermen to enter the industry but only by buying a quota from an existing quota holder**

RECOMMENDATIONS

- **At the same time, many fishermen will have to find other means of employment and should be given help to do this**
- **Tradable quota system should be complemented by alternative livelihood projects to wean fishermen and their families off of fishing**
- **Integrated coastal management plan to develop alternative sources of income that will reduce fishing pressure on the bay, making both fishing and the wider local economy sustainable.**