Ghana Artisanal Marine Sector Case Study Results
Ghana Fisheries and Seafood Bio-economic Assessment Model Project

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Foreword

This report was prepared under guidance from Gilbert Sylvia, Ph.D. Dr. Sylvia is president of SylDon Inc. located in Newport, Oregon and also Superintendent of the Coastal Oregon Marine Experiment Station, Oregon State University. Shannon Davis (President of The Research Group, Corvallis, Oregon) assisted Dr. Sylvia. The project was sponsored by New Partnership for Africa's Development (NEPAD) and is titled "Development of a Policy and Investment Scenario Analysis Model of the Ghana Fisheries and Aquaculture Sector Project." The project started in the summer 2010 and is slated to end in summer 2011.

An element of the project was to provide interim modeling results to evaluate the economic effects from a proposed fishing industry investment project sponsored by the World Bank's West Africa Regional Fisheries Program (WARFP). The *original* WARFP investment project analysis that contains summary effects for all fishing industry sectors can be found in the report "Program Economic and Financial Analysis: Ghana Fisheries and Aquaculture Program" completed by SylDon Inc. for the World Bank in October 2010. The all-sector report also provides digest descriptions for the different WARFP investment project components. Full descriptions about expected loan and grant financing arrangements and project components are in the WARFP Project Appraisal Document (PAD) being developed by the World Bank.

This report contains *updated* modeling results from the analysis of the WARFP investment project as it applies to the artisanal marine sector. The difference between the original and updated analysis is that the fish resource model component had not yet been perfected for the original analysis and rather than harvest projections being based on sustainable yield relationships, the harvests were supplied to the model using expert judgment.

The report has not been reviewed by project sponsors or other independent reviewers. The project participants and not the sponsors are responsible for project results. The participants do not assume any liability for use of the information and shall not be responsible for any damages that might arise from information use. Questions and comments should be directed in writing to Dr. Sylvia at COMES, Oregon State University, 2030 Marine Science Drive, Newport, Oregon 97365 USA or gil.sylvia@oregonstate.edu.

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Ghana Artisanal Marine Sector Case Study Results

A. Introduction

This report provides descriptions and modeled impact results for altering how Ghana fisheries are managed. The model used to derive results is termed the Ghana Fisheries and Seafood Bio-economic Assessment Model (GFSBAM).[1] The modeled results are generated from supplying independent variable values and making other expert judgments about future fishing industry sector conditions. While the results summarize changes to all fishing industry sectors, only information about the artisanal marine sector is presented in this report. This particular sector has protection and enhancement priority in the Fisheries and Aquaculture Policy adopted by the Government of Ghana in 2008.

The assumed changes represent what might happen if a proposed World Bank West Africa Regional Fisheries Program (WARFP) investment project is implemented. The investment project is a grant/loan package to improve fishery management and provide facilities and services to all of Ghana's fishing industry sectors. The Ghana artisanal marine sector is targeted as the prime benefactor for the proposed project. Profile information including recent year's catch and effort trends is provided.[2] A sensitivity analysis for important modeling performance indicators is also provided.

1. A description of the assumptions and methods used to develop the model are contained in the GFSBAM Operational Guide (SylDon 2011).
2. Catch volume is in units of metric tons (mt). Any reference to value in the report is in year 2009 United States Dollars (USD). Currencies were converted to nominal USD using exchanges rates from OANDA Corporation, http://www.oanda.com/currency/historical-rates, as reported in a Wikipedia article on October 17, 2010 at http://en.wikipedia.org/wiki/Ghanaian_cedi. U.S. dollars adjusted to 2009 using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.

The GFSBAM's utility is designed to compare effects from two alternatives rather than a normative forecast of before-and-after conditions. The alternatives are associated with an action (termed the investment case) and without an action (termed the base case).[1] There are many fishing industry performance indicators that are outputs from the model. The outputs are shown in static dimensions (certain future cross-sectional year) and dynamic dimensions (net present value over the projected time horizon). This report focuses on dynamic changes to net economic benefits, potential limited entry permit transaction values, and generated resource rents.

B. Sector Landings and Vessels

Several existing studies have qualitatively described the importance of the artisanal marine sector as a source of family income in Ghana, especially during the cyclical months when pelagic fish species are near the coastline (Entsua-Mensah 2006; ICSF 2002; Mensah et al. 2006). A comprehensive program to acquire quantitative data about catch and harvest first-purchase value does not exist in Ghana. The Ghana Department of Fisheries is aware of major landing locations and provides some assessments of effort and deliveries for their annual catch reports through fisher interviews at those locations (Table 1 and Figure 1). The annual catch reports update the most recent census information taken in 2004 (Amador et al. 2006).

The historical catch and effort data series used to develop model relationships contains gaps and discrepancies. It was necessary to use imputations and averaging to determine initial

1. The economic and biological modeling results are garnered from a model that is still in development. The net economic benefits and other measures provided in this report will change as more information and knowledge about the Ghana fishing industry is incorporated into the GFSBAM.

conditions.[1] Initial conditions total estimated catch is 232 thousand mt and total revenue USD $440 million. The catch represents 36 percent of total reported catch for all sectors in Ghana (Figure 2). The fishery harvests are largely comprised of pelagic and demersal finfish species. The share of initial conditions total catch for the top landed species are sardinella (31 percent), mackerel (three percent), anchovy (16 percent), seabreams (six percent), and burrito (eight percent). Some cephalopods (cuttlefish, etc.) and crustaceans (shrimp, etc.) are also harvested.

Labor payment shares include taking catch in lieu of monetary exchange. Assuming landing data includes the catch diverted to this purpose, then estimated harvest revenue would include an equivalent value for the subsistence portion. In other words, it is assumed families would have to purchase seafood if it was not diverted.

The vessels in the artisanal marine sector are canoes that can range in length from four to 20 meters. Canoes can be manually paddled or powered by an outboard motor. It is important to distinguish the two power source categories because operational costs are much different. The share of operational costs for labor are higher for the non-motorized fleet, and the share of fuel and gear costs are higher for the motorized fleet. The motor powered fleet tends to use APW and gillnet gear more than the non-motorized fleet which relies more on beach seines and set-nets (FAO Big Numbers Project 2008).[2] Lagas canoes are larger motorized canoes that pack ice and spend multiple days at sea.

1. Landing data vagrancies require several assumptions to be used to establish an "initial condition" profile for landings and canoe counts. (Initial conditions are the starting year for the model's 30 year projection horizon.) Assumptions include using recent year averages instead of the most recent year data for a modeling starting year. Shoulder year catch and value are imputed to make average periods complete.
2. APW is an acronym for ali, poli, and watsa type net gear. This net gear has similar features as purse seine gear. It is the main gear used to catch sardinella fish (Koranteng 1996). The poli and watsa nets are used when the

There are species price differentials for the motorized and non-motorized canoes. Size, post-catch care, and delivery amounts can all influence price. Motorized canoes tend to deliver larger unit quantities and will use ice to care for harvests until landings are made. The mix of species delivered by the two canoe power source categories would affect the overall value of landings for the categories. Non-motorized canoe deliveries would be mostly smaller pelagic species and motorized canoe deliveries would land higher priced demersal and larger pelagic species.

The Ghana Department of Fisheries landing reports do not provide first-purchase value information for the canoe power source categories, so assumptions were made for prices using proxy information. The price differential proxy information was from Senegal (personal communication Jingjie Chu, November 2010). It was assumed the species aggregated average first-purchase price percent difference for the non-motorized canoe category was a minus 20 percent. The motorized canoe landing value was adjusted to preserve the total sector landed value.

Annual landing information is reported by gear types, however there were no validated studies discovered that show proportion of canoe power source category catch share for each of the gear groups. Reasonable assumptions were made based on available literature to allocate catch shares across gear and canoe categories. Using landings by gear type (Table 2), and study assumptions about proportions of canoes by gear type (Table 3), trends and initial conditions landing estimates for the two categories were derived (Table 4).

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fish are schooling and the ali net is used when the fish are scattered, normally at the beginning or towards the end of the sardinella season. The poli net has a 10 mm stretched mesh size.

Assignments of the proportion of canoes in power source categories by gear type would mean that catch per vessel is assumed to be the same within a gear category for motorized and non-motorized canoes. Given powered canoe capacity differences (travel further to more productive fishing grounds, use larger nets, etc.), the constant catch per vessel assignment would probably represent the maximum catch rate for non-motorized canoes. The sensitivity of the assumed catch rate for determining total and per vessel catch by power source categories is shown in Table 5.

The number of current active vessels participating in the Ghana artisanal marine sector is an estimate. The current status of an unenforced licensing program is that registrations are voluntary. The count in 2004 was 11,213 (Amador et al. 2006), which represents a 12 percent increase from the previous survey done in 2001. The informal assessments since then have estimated as high as 200 net vessel increases (entrances less number exiting) per year. The number used for initial conditions is 11,213 (Table 6 and Figure 3). However, it is possible that the contemporary fleet may be higher or lower than the fleet in 2004 -- anecdotal evidence and trend data suggest the fleet may include an additional 1,000 to 1,500 canoes in 2010.

The annual average percent difference in landing volume (-1 percent) and value (-2 percent) shows overall decreases between 2002 and 2007 (Table 6). There are yearly higher and lower spikes within this period probably associated with changed fishery stock abundances due to ocean upwelling conditions. During this same period, annual average percent difference in catch per vessel decreased by -4 percent (Figure 4). If landing data and vessel count accuracy is

accepted and the catch per vessel ratio can be considered a catch per effort statistic, this trend indicator raises a concern for the health of the fishery stock's biomass.

C. Model Results

The GFSBAM is a deterministic and dynamic representation of Ghana fisheries. The model is bio-economic in that it includes feedback loops between stock size changes and economic sector production. The model includes multiple fisheries and multiple sectors so that changes in any one sector will causes changes to another sector within a fishery. The model was calibrated using an eight year data series. Effort is an independent variable so that sector constraints can be introduced to calculate future fishery status.[1] The exogenous inputs are derived from expert judgment about policies and management that would accompany the WARFP proposed investment project. Modeled outcomes are provided based on dependent variable calculations for harvest response to stock abundance changes, harvesting and processing practices, aquaculture development, and seafood market conditions. Rational participant behavior and non-distorting government policies are the assumed hallmarks for the expert judgment.

The modeled Ghana fisheries and sector structure is shown on Table 7 for initial conditions. The assessed fisheries shown on the table represent landings when species and gear information was available for making fishing classifications. Based on initial conditions, the 33.3 percent of mixed species group landings are added as the relative proportion of assessed species future harvests.

1. The model was designed to allow certain decision variables to be conveniently changed in order to show sensitivity in important parameters (such as depreciation schedules, investment loan terms, social discount rates, etc.). Planned system complexity improvements will allow other variables that are now hard-wired to be converted to decision variables.

A Gordon-Schaefer surplus production function was fit to each of Ghana's fisheries using best fit procedures for three factors: intrinsic growth rate, carrying capacity, and biomass.[1] The assumed equilibrium conditions (calibrated from initial conditions and trends) generated the sustainable yield curves for the artisanal marine sector's fisheries as shown in Appendix A. Stock status as defined by ratios for fishing mortality and biomass compared to calculated maximum sustainable yield levels is also shown in Appendix B.

The model's inputs/drivers for the cases are shown in Appendix C. The algorithms for the many derived indicators that were projected over the project's 30 year horizon are shown in Appendix D. The projection of performance indicators for landings and vessel counts by canoe power source categories are shown on Figure 5.

D. Net Economic Benefits

Net economic benefits are net revenue plus labor less depreciation and less opportunity costs. Net revenue from fisheries is estimated as total revenue minus operational costs. Operational costs include trip variable costs (fuel, bait, expendable gear, etc.) and non-trip fixed costs (moorage, etc.). Labor costs for skipper and crew in Ghana are based on a catch share system (Koranteng et al. 1993; Amador et al. 2006). In some cases vessel owner family and extended family members largely comprise the skipper and crew positions. Cost-earnings studies (Seini, A. Wayo 1995; and, FAO Big Numbers Project 2008) which were substantiated using author field interviews during August 2010 are shown on Table 8. The studies were relied upon for determining pro forma income statements that itemize revenue and operational costs (Table 9).

1. The surplus production function is described in articles by Gordon (1954) and Schaefer (1957).

Depreciation and capital costs are separately estimated as annual costs for each canoe power category. Assumptions were made about hull, motor, gear, and other equipment lifespan and salvage value to calculate straight-line depreciation; and, other assumptions were promulgated for loan terms to determine opportunity cost of capital. Opportunity cost of labor is the estimated share of labor costs for workers finding alternative employment at same or higher wages.

Using initial condition landing information and vessel numbers, per vessel total revenue is USD $51.9 thousand and $22.4 thousand for motorized and non-motorized canoes respectively (Table 10). The pro forma income statements provide the share of total revenue going to variable expenses: 42 percent and 33 percent for the motorized and non-motorized canoe categories. The fixed expenses were $7.8 thousand and $1.1 thousand. This resulted in the cash flow before depreciation and capital costs to be $22.3 thousand for the motorized and $14.0 thousand for the non-motorized canoes. This cash flow would be considered gross profit and include the returns to owners. For Ghana fisheries, sometimes there are different owners of the hull, motor, and gear all of which have pre-determined catch share claim of available cash flow.

Theoretically, depreciation and cost of capital can be aggregated and associated with a vessel. In practice, these costs are a distributed to owners with different equity situations. No second tier accounting was undertaken to disaggregate the non-cash deprecation calculation nor the opportunity cost for capital for different owners. The aggregated cost of capital was simply estimated to be an annual amortized payment schedule given assumed loan terms. The estimated

capital cost for canoes used a rule-of-thumb to be equal to one year average total revenue. This estimate was consistent with several independent studies' findings, including the FAO Big Numbers Project (2008). Motorized canoe initial condition annual depreciation and cost of capital was $5.2 thousand and $8.3 thousand per vessel respectively. Non-motorized canoe initial condition annual depreciation and cost of capital was $2.2 thousand and $3.6 thousand per vessel. This results in a per vessel net economic benefit calculation of $15.8 thousand and $11.7 thousand for the two canoe vessel types in initial conditions.

The total net economic benefit over the project horizon for the base, investment, and case differences (net benefit) is shown in Table 11 and Figure 6.[1] The interpretation for the net benefit calculation is that the WARFP project would result an increase of $350 million in economic wealth from the artisanal marine sector over the 30 year project horizon. Table 12 shows the sensitivity of the wealth increase to assumed discount rates.

E. Potential Permit Value

There are concerns for the continued business viability of the artisanal marine sector due to the increasing numbers of participants and decreasing catch per vessel. In a harvest regime with unconstrained participants, it is difficult to manage a fishery for over-exploitation. Setting annual total harvest quotas to protect stocks from overfishing will encourage concentrated effort to secure as much catch as possible per vessel before quotas are reached (Hinman and Paulsen 1993). It is of interest to know the license economic value if a limited entry program was

1. A benefit cost analysis for the WARFP project is shown in Appendix D. Project costs include an assumed annual O&M $5 million from Ghana Government for increased management and enforcement. New fishing industry transfer payments through license fees uses a half percent harvest value assumption. The all sector discounted net benefits for the project is a positive $98 million and the benefit-to-cost ratio is 2.49. The internal rate of return for the net benefits is 15.1 percent.

imposed. The license economic value in this case can be theoretically calculated as opportunity cost representing the "indifference" value to where the benefits of fishing are equal to the benefits of selling the license. For a buy-out program, it would be the value for loosing expected income in perpetuity. For a rent-out program, it would be the loss of income for a year. Such programs are short-term solutions to rationalize fishing effort to a level consistent with economic and ecological sustainability. If such policies are implemented, decisions for assisting displaced participants secure long-term adjustments may need to be considered.

The pro forma income statement results can be used to estimate that value of a limited entry permit given additional assumptions about participant economic behavior. It was assumed that the labor market works smoothly in the region and that participants in the artisanal fishery could find work outside the fishery. If the fishers use family labor to work the canoes, then their opportunity cost would increase by an amount equal to any difference between the wage the fishers could obtain in other economic activity and their implicit artisanal fishers' wage. We have little information on the set of skills of fishers' families and alternative employment possibilities, thus we simply assume there is a 50 percent probability that alternative labor opportunities exist for same or higher wages.

The opportunity cost of not fishing for a year can be used directly to estimate the cost of a "rent-out" to temporarily reduce fishing effort. Permit holders should be willing to accept a payment of an amount equal to their expected revenue less variable costs to forego fishing for one year.

The cost of a permanent "buy-out" of a permit would be equal to the discounted stream of expected net profits and lost labor income in perpetuity. Lost labor income would be the probability that higher wages could not be found in another industry. To show an upper and lower range for a permit value, we provide an estimate using only net profits for the lower bound and net profits plus the probability that alternative wages cannot be found in another fishery or non-fishing industry for the upper bound. If catches were constant and the discount rate was 10 percent per annum, the value of a permit would be approximately 11 times the annual net profits (lower bound) or net profit plus 50 percent labor (upper bound). The initial conditions and Year 10 model results for the base and investment cases are shown in Table 10. Using the base case, a per vessel buy-out program weighted average over canoe categories for a lower and upper bound for one permit would be $79 thousand and $163 thousand at a five percent discount rate; $49 thousand and $100 thousand at a 10 percent discount rate; and $26 thousand and $53 thousand at a 20 percent discount rate. Other permit value sensitivity to financial parameter assumptions are shown in Table 13.

These preliminary estimates of license permit economic value are useful for policy decision making at early stages of designing a buyout program. Measures of value and uncertainty could also be estimated through the use of a contingent valuation study. A second way to estimate permit values would be observing permit sales results in a limited entry system. This second way would require a delay in implementing a buy-out/rent-out program.

There are many examples in other countries for buyout programs conducted as reverse auctions. The structuring of buyout program financing and institutional arrangements can take many forms

in order to accomplish the goal for reduced fishing capacity. Insights on how bid prices compared to derived license values can be found in Squires (2010). Programs may address retiring physical, labor, and technological capacity in order that gains are made in the efficiency for the remaining participants. If there are gains, the program arrangements could be in the form of a loan to industry with payment expected from the remaining participants. Credible prediction for gains would have to address the highly variable latent capacity that exists in any industry with low ease-of-entry. The design of a buyout program for Ghana artisanal fisheries will be complicated by the local acceptance for a limited entry permit requirement and the ability to enforce the requirement. Planning for limited entry can include attrition elements (such as canceling permits if annual fees are not received) which will accomplish reduced capacity, albeit at slower rates of decrease.

F. Resource Rent

Net economic benefits are sometimes referenced as economic rent which should not be confused with the concept of resource rents. Net economic benefits in the model are returns to owners and participants including skippers/crew after all variable and fixed costs as well as depreciation and opportunity costs are accounted. Resource rents are total revenues minus all economic costs and further assume there is an allowance for normal profit. Normal profit in fisheries would take into consideration the risky variables in which investors do not have control in the hope of getting acceptable returns. Lange and Motinga (1997) used a margin of 20 percent in the calculation of resource rents in the Namibian hake fishery and the same assumption is adopted in this project's modeling.

The artisanal marine sector resource rent is positive for both the investment case and base case for each projection year (Table 14). The Year 15 static measure for resource rent is 29.6 percent higher in the investment case than the base case when total effort is less by 17.8 percent. Higher resource rent for artisanal marine sector investment case is buoyed by the decrease in effort in the other sectors that are harvesting in the same fishery (see Table 7 for the other sectors). The increase in resource rent despite lower effort indicates the potential value of government intervention to curtail open access behavior. Without intervention to control effort, increasing number of vessels would harvest an ever decreasing stock size.

Resource rents per vessel represent an important measure of efficiency. Any increase in efficiency would signal the potential for capturing resource rent increases for public benefits. As expected, higher per vessel resource rents are found in the investment case (Table 14). On a per vessel basis, the non-motorized canoe sector has higher resource rent than the motorized canoe sector due to the assumptions regarding harvests and prices, and the higher per vessel labor shares (benefit in the calculation) and lower capital costs (deduction in the calculation). The per vessel NPV for resource rents and sensitivity to discount rates for the base case are shown on Table 15.

More dramatic changes to effort were simulated using the GFSBAM.[1] The base case assumed effort constraints were changed to the initial condition's maximum economic yield levels (Table 16). This significant restructuring of the sector would reduce vessels by 49.3 percent, but NPV resource rent would be raised over the base case by 12.6 percent or 13.2 percent. The two

1. The model assumes the fleet and processors are perfectly malleable in that existing infrastructure can be transformed to handle the increased catch.

increases are whether the restructuring occurred in one year or was spread over a 25 year period, both starting in Year 6. The increased benefits to the economy are from greatly reduced capital devoted to fishing. The lesser number of vessels would mean decreased labor requirements. These labor adjustments may represent social consequences and tradeoffs that decision makers would have to consider for imposing management restrictions.

A less than optimal resource rent implies that the fishery is not being managed for efficiency and sustainability. Under a more effective management regime designed to generate high sustained economic yields, the fishing industry could realize greater harvests, higher prices, and/or reduced harvest prosecuting costs to generate increased resource rents. With positive resource rents, the Ghana government can capture excesses through fees or taxes to offset management, enforcement, and subsidy costs. Akpalu and Vondolia (2011) explores fee amounts that could be extracted from the semi-industrial and industrial (including tuna vessels) sectors. Developing institutional arrangements and designing/setting fee and tax levels is a challenging endeavor because of the friction between fishing businesses wishing to maximize their income and government wanting reimbursement for industry support costs. Finding the "best" structure and the level of transfer payments from the private sector to government will be difficult. The amount needs to be adequate for cost recovery, balanced among sectors, and imposed with objectives to promoting efficiency.

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Table 1
Ghana Artisanal Marine Sector Catch and Value by Species in 2001 to 2008

Species	2001	2002	2003	2004	2005	2006	2007	2008
				Catch (Thousands of Metric Tons)				
Round Sardinella	64.1	59.4	70.3	78.5	61.2	66.3	35.5	21.4
Flat Sardinella	15.9	13.7	15.4	27.1	14.2	21.1	10.0	15.7
Chub Mackerel	9.6	5.4	4.3	3.2	2.5	3.4	2.8	2.7
Anchovy	68.2	57.6	82.9	52.6	35.6	44.9	10.1	40.6
Frigate Mackerel	7.3	3.6	2.9	4.3	4.2	2.9	5.6	4.9
Seabreams	7.0	4.7	5.4	4.3	18.0	10.6	24.3	14.0
Burrito	12.4	7.6	6.7	24.8	15.8	18.4	21.0	16.7
Others	51.9	48.7	50.9	73.1	67.3	64.2	77.8	138.1
Total	236.4	200.8	238.8	267.9	218.9	231.7	187.1	254.1
				Value (Thousands of U.S. Dollars 2009 Real)				
Round Sardinella	n/a	55,157	115,430	134,201	107,891	124,743	83,885	56,310
Flat Sardinella	n/a	12,419	26,949	46,275	24,960	39,746	23,624	41,379
Chub Mackerel	n/a	5,455	8,869	5,497	4,488	6,318	6,517	7,077
Anchovy	n/a	35,428	106,155	90,026	62,815	84,413	23,850	106,888
Frigate Mackerel	n/a	5,442	5,551	7,441	7,321	5,433	13,349	12,843
Seabreams	n/a	7,635	22,749	7,395	31,695	19,990	57,553	36,954
Burrito	n/a	4,796	7,757	42,368	27,895	34,545	49,766	43,988
Others	n/a	86,817	168,178	125,077	118,634	120,828	184,063	363,421
Total	159,248	207,354	461,638	458,280	385,700	436,015	442,609	668,859
				Price (U.S. Dollars 2009 Real Per Metric Ton)				
Round Sardinella	n/a	928.57	1,641.63					
Flat Sardinella	n/a	906.96	1,747.73					
Chub Mackerel	n/a	1,004.87	2,057.77					
Anchovy	n/a	614.65	1,280.06					
Frigate Mackerel	n/a	1,496.85	1,922.72					
Seabreams	n/a	1,610.47	4,249.80					
Burrito	n/a	633.32	1,165.53					
Others	n/a	1,784.23	3,302.28					
Aggregate	673.77	1,032.80	1,933.19	1,710.58	1,762.22	1,881.97	2,365.78	2,631.92

Notes: 1. Table cells showing n/a are for data that is not available or has unresolved issues.
2. The data source relied upon the shown aggregate price for determining the value for each species.
3. Sector totals do not match volume and value by sector from Table 6 because data sources are different.

Source: Marine landings and revenue data by species are from personal communication with Kofi Amador, Ghana Department of Fisheries, 2010.

Table 2
Ghana Artisanal Marine Sector Catch (mt) by Gear in 2000 to 2008

Canoe	2000	2001	2002	2003	2004	2005	2006	2007	2008
APW	215,495	184,266	138,548	164,788	154,947	125,784	139,292	103,262	140,472
Beach seine	33,652	22,973	33,070	39,333	73,848	43,250	47,561	30,669	41,720
Hook & line	8,275	9,277	10,192	12,123	12,640	20,880	15,967	13,445	18,289
Set net	11,305	11,912	9,706	11,545	12,580	17,396	17,185	29,602	40,269
Drifting gill net	7,549	11,597	9,308	11,071	13,895	12,324	11,674	9,838	13,383
Total	276,275	240,025	200,825	238,860	267,910	219,634	231,681	186,816	254,133

Notes: 1. Canoe gear breakdown in 2003 is corrected using 2002 proportions of total canoe. Canoe drifting gill net in 2007 is corrected by a factor of 100.
2. Total does not match Table 6 because data sources are different for years 2000 to 2007. Year 2008 is from Table 6. Gear breakdown for 2008 is estimated using 2007 proportions for canoe and tuna sectors.

Source: Personal communication, Doris Yeboah, Ghana Department of Fisheries, 2010.

Table 3
Assignment of Motorized Canoes by Gear Type for Initial Conditions

	Initial	Motorized	
Gear Type	Conditions	Share	Number
Canoes (Total)	11,213		6,414
Beach Seine	903	25%	226
Pursing Nets	2,597	90%	2,337
H&L	933	79%	737
Ali	1,855	90%	1,670
Other Set Net	3,004	27%	811
Lobster Set Net	871	19%	165
DGN	520	90%	468
One Man Canoe	530	0%	0
Subtotal APW	4,452	90%	4,007
Subtotal Set Net	4,405	22%	977

Source: Study.

Table 4
Assumed Catch (mt) and Share by Gear for Motorized Canoe Category

Canoe	2000	2001	2002	2003	2004	2005	2006	2007	2008
APW	193,945	165,839	124,693	148,310	139,452	113,206	125,363	92,936	
Beach seine	8,413	5,743	8,268	9,833	18,462	10,813	11,890	7,667	
Hook & line	6,538	7,328	8,052	9,577	9,985	16,495	12,614	10,621	
Set net	2,506	2,641	2,152	2,559	2,789	3,857	3,810	6,563	
Drifting gill net	6,794	10,438	8,377	9,964	12,506	11,091	10,507	8,854	
Total	218,196	191,989	151,542	180,243	183,194	155,462	164,184	126,641	
share	79%	80%	75%	75%	68%	71%	71%	68%	68%

Notes: 1. Catch share for motorized canoes assumes assigned canoe power source proportions in Table 3 applied to catch by gear type in Table 2.

Source: Study.

Table 5
Ghana Artisanal Marine Sector Power Source Category Total and Per Vessel
Initial Condition Harvest Value Sensitivity to Assumed Catch Rates

	Catch Rate			
Power Source Category	25 Percent	50 Percent	75 Percent	100 Percent
Motorized				
Total ($000)	413,287	386,333	359,378	332,424
Per Vessel	64,526	60,317	56,109	51,901
Non-motorized				
Total ($000)	26,954	53,909	80,863	107,817
Per Vessel	5,606	11,212	16,818	22,425
Total				
Total ($000)	440,241	440,241	440,241	440,241
Per Vessel	39,262	39,262	39,262	39,262

Notes: 1. The table measure is initial condition harvest value in 2009 USD real. Total harvest value is in thousands.
2. Catch rate is the percent difference for non-motorized canoe from the assigned gear averages (Table 3). The motorized canoe harvest value is adjusted so that the total combined landing harvest value is preserved.

Source: Study.

Table 6
Ghana Artisanal Marine Sector Vessels and Landings by Power Source Category in 2000 to 2008 and Initial Conditions

Power Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	Initial Conditions	Annual Percent Difference
					Number of Vessels						
Motorized	5,139	5,256	5,256	5,256	6,405	6,405	6,405	6,405	6,405	6,405	4%
Non-motorized	3,471	4,725	4,725	4,725	4,808	4,808	4,808	4,808	4,808	4,808	0%
Total	8,610	9,981	9,981	9,981	11,213	11,213	11,213	11,213	11,213	11,213	2%
					Catch (Thousands of Metric Tons)						
Motorized	218.2	189.1	151.5	180.2	183.2	154.9	164.2	126.8	172.3	160.3	(3%)
Non-motorized	58.1	47.3	49.3	58.6	84.7	63.9	67.5	60.3	81.9	71.7	4%
Total	276.3	236.4	200.8	238.8	267.9	218.9	231.7	187.1	254.1	231.9	(1%)
					Value (Thousands of U.S. Dollars 2009 Real)						
Motorized	n/a	n/a	362,387	373,152	345,243	305,183	336,145	343,125	343,125	332,424	(1%)
Non-motorized	n/a	n/a	88,524	91,154	116,910	93,095	102,153	119,112	119,112	107,817	7%
Total	n/a	n/a	450,912	464,306	462,153	398,277	438,298	462,237	462,237	440,241	1%
					Catch Per Vessel (Metric Tons)						
Motorized	42.5	36.0	28.8	34.3	28.6	24.2	25.6	19.8	26.9	25.0	(6%)
Non-motorized	16.7	10.0	10.4	12.4	17.6	13.3	14.0	12.5	17.0	14.9	4%
Total	32.1	23.7	20.1	23.9	23.9	19.5	20.7	16.7	22.7	20.7	(3%)

Notes: 1. Numbers showing in parenthesis are negative.
2. Annual average percent difference is for years 2002 to 2007.
3. Assignment of landings to canoe power source categories uses assumptions for gear use showing in Table 3.

Source: Marine landings data and vessel counts are from personal communication with Doris Yeboah, Ghana Department of Fisheries.

Table 7
Ghana Fisheries and Sector Structure

		Sectors								
		(a)	(b)	Industrial			(d)	Marine	(f)	All
Model	Fishery	Marine Canoe	Semi-Industrial	(c) Trawl	(e) Shrimp	Total	Tuna	Assessed Total	Fresh-water	Fisheries Total
(1)	Small pelagic	14.8%						4.5%		
(2)	Medium/large pelagic	3.2%	8.0%					1.1%		
(3)	Migratory pelagic	33.2%	30.5%	2.0%		2.0%		10.6%		
(4)	Demersal	15.4%	3.9%	31.2%	0.2%	31.5%		6.3%		
(5)	Cephalopod		0.1%	13.7%	0.6%	14.4%		0.7%		
(6)	Small tuna						61.7%	6.6%		
(7)	Large tuna						28.1%	3.0%		
(8)	Shrimp				1.1%	1.1%		0.1%		
(9)	Freshwater								100.0%	
All fisheries										
	Assessed share	66.7%	42.5%			48.9%	89.9%	32.9%	100.0%	46.3%
	Mixed group share	33.3%	57.5%			51.1%	10.1%	67.1%	0.0%	53.7%
	Total share	100.0%	100.0%			100.0%	100.0%	100.0%	100.0%	100.0%

Notes:
1. Costs include fishing variable and annual fixed costs, opportunity cost of capital and labor, and depreciation.
2. Canoe sector fishery revenue share assumed to be the same for the two power source categories. Industrial sector cost per vessel assumed to be the same for the two gear categories.
3. Marine assessed fisheries are those for which a bio-economic model has been developed. The share of each sector's total revenue and share of all fisheries revenue not assessed is shown in the row "mixed group share."

Table 8
Canoe Vessel Cost-Earnings Budgets in 1977 and 1992

Table 8a
Capital Costs (000 Cedis 1977 constant)

	1986	1989	1992	Average		Per Vessel
Hull	5.41	8.76	6.95	7.04	20.0%	0.87
Gear	18.17	29.86	24.04	24.02	68.3%	2.98
Motor	4.33	3.53	4.54	4.13	11.7%	0.51
Total	27.91	42.15	35.53	35.20	100.0%	4.37

1992	
Vessels	8,052
Production (mt)	371,000
Marine	308,000
Share of marine	83%

Table 8b
Profit Per Vessel (Cedis)

1977	Capital	Fixed and Variable	Total	Revenue	Gross Profit
Motorized	1,733	3,400	5,133	5,961	828
Percent	29%	57%			14%
Non-motorized	289	214	503	567	64
Percent	51%	38%			11%
Total	2,022	3,615	5,636	6,528	892
Percent	31%	55%			14%
1992					
Total	3,530	6,967	10,497	11,408	911
	31%	61%			8%

Table 8c
Variable Costs (percent)

	Repair and Maintenance					
1977	Motor	Canoe	Net	Fuel	Labor	Food
Motorized	5.4%	1.1%	3.5%	40.4%	47.5%	2.2%
Percent						
Non-motorized	0.0%	1.8%	7.1%	0.0%	85.3%	5.8%
Percent						

Table 8d
Model Pro Forma Income Statement Assumption

	Labor	Other Variable	Fixed	Variable	Capital	Profit Net	Profit Gross
1977							
Motorized	27%	15%	15%	57%	29%	14%	43%
Non-motorized	32%	1%	5%	38%	51%	11%	62%
1992							
Total				61%	31%	8%	39%

Notes: 1. Table 8d shows the assumed operational and capital cost shares from Tables 8a-8c information.
Source: Seini, A. Wayo (1995).

Table 9
Ghana Artisanal Marine Sector Pro Forma Income Statement

	Canoe Type	
	Motorized	Non-motorized
Capital (years earnings rule)	1	1
Gross earnings	100.0%	100.0%
Variable cost	14.9%	0.5%
Fixed cost	15.0%	5.0%
Labor	27.1%	32.2%
EBITDA	43.0%	62.3%
Net profit	14%	11%
Crew per vessel		
Captain	1	1
Crew	15	10

Notes: 1. Capital investment includes hull, gear, engine, and electronics.
2. EBITDA - gross earnings before interest, taxes, depreciation, and amortization, which is sometimes called cash flow.

Sources: Study; FAO Big Numbers Project (2008); Seini, A. Wayo (1995); Personal communication, Doris Yeboah, 2010.

Table 10a
Ghana Artisanal Marine Sector Per Vessel and Total Model Results for Initial Conditions

	Motorized Canoe	Non-Motor. Canoe	Total
Per Vessel			
Harvest weight (mt)	25	15	21
Gross earnings (USD 2009)	51,901	22,425	39,262
Capital	51,901	22,425	39,262
Labor cost	14,061	7,219	11,128
Other variable expenses	7,756	123	4,483
Fixed expenses	7,785	1,121	4,928
EBITDA	22,298	13,961	18,723
Net profit	7,209	2,531	5,203
Capital cost	8,292	3,583	6,273
Depreciation	5,190	2,242	3,926
Opportunity cost	15,322	7,192	11,836
Net economic benefit	15,847	11,746	14,088
Asset value (lower bound)	109,147	38,322	78,778
Asset value (upper bound)	215,591	92,973	163,014
Resource rent	5,467	7,261	6,236
Employment	16	11	14
Total (Thousands)			
Harvest weight (mt)	160	72	232
Gross earnings (USD 2009)	332,424	107,817	440,241
Capital	332,424	107,817	440,241
Labor cost	90,063	34,711	124,774
Other variable expenses	49,680	591	50,271
Fixed expenses	49,864	5,391	55,254
EBITDA	142,818	67,124	209,942
Net profit	46,175	12,170	58,345
Capital cost	53,109	17,225	70,334
Depreciation	33,242	10,782	44,024
Opportunity cost	98,140	34,581	132,721
Net economic benefit	101,498	56,473	157,972
Asset value (lower bound)	699,085	184,252	883,337
Asset value (upper bound)	1,380,862	447,015	1,827,878
Resource rent	35,014	34,910	69,923
Employment	102	53	156

Notes:
1. Initial conditions vessel counts use most recent year (2005) available. Harvest weight uses 2004-2008 average. Gross earnings uses 2004-2007 average landed value (in real 2009 USD).
2. EBITDA - earnings before interest, taxes, depreciation, and amortization, which is sometimes called cash flow.
3. Asset value is net present value of net profit stream in perpetuity considering discount rate for the base case.
4. Capital is assumed purchase price for hull, engine, gear, electronics.
5. Capital cost is amortization payment schedule for assumed loan terms.
6. Depreciation cost uses straight-line method with zero salvage value.
7. Opportunity cost is capital cost plus probability labor has higher wages in alternative employment.
8. Net economic benefit is EBITDA plus crew/captain labor less depreciation and less opportunity cost.
9. Resource rent is net economic benefit minus allowance for normal profit.

Source: Study.

Table 10b
Ghana Artisanal Marine Sector Per Vessel and Total Model Results for Base Case Year 10

	Motorized Canoe	Non-Motor. Canoe	Total
Per Vessel			
Harvest weight (mt)	21	13	18
Gross earnings (USD 2009)	44,036	19,027	33,312
Capital	44,036	19,027	33,312
Labor cost	11,931	6,125	9,441
Other variable expenses	6,581	104	3,804
Fixed expenses	6,605	951	4,181
EBITDA	18,919	11,845	15,886
Net profit	6,117	2,148	4,415
Capital cost	7,035	3,040	5,322
Depreciation	4,404	1,903	3,331
Opportunity cost	13,001	6,102	10,043
Net economic benefit	13,445	9,966	11,953
Resource rent	4,638	6,161	5,291
Employment	16	11	14
Total (Thousands)			
Harvest weight (mt)	162	73	235
Gross earnings (USD 2009)	336,596	109,170	445,766
Capital	336,596	109,170	445,766
Labor cost	91,193	35,147	126,340
Other variable expenses	50,303	598	50,901
Fixed expenses	50,489	5,459	55,948
EBITDA	144,610	67,967	212,577
Net profit	46,754	12,323	59,077
Capital cost	53,775	17,441	71,216
Depreciation	33,660	10,917	44,577
Opportunity cost	99,372	35,015	134,386
Net economic benefit	102,772	57,182	159,954
Resource rent	35,453	35,348	70,801
Employment	122	63	186

Notes: 1. See Table 10a for definitions.
2. Base case assumptions are shown in Appendix C.

Source: Study.

Table 10c
Ghana Artisanal Marine Sector Per Vessel and Total Model Results for Investment Case Year 10

	Motorized Canoe	Non-Motor. Canoe	Total
Per Vessel			
Harvest weight (mt)	27	16	23
Gross earnings (USD 2009)	57,319	24,766	43,361
Capital	57,319	24,766	43,361
Labor cost	15,529	7,973	12,289
Other variable expenses	8,566	136	4,951
Fixed expenses	8,598	1,238	5,442
EBITDA	24,626	15,418	20,678
Net profit	7,962	2,795	5,747
Capital cost	9,157	3,957	6,927
Depreciation	5,732	2,477	4,336
Opportunity cost	16,922	7,943	13,072
Net economic benefit	17,501	12,972	15,559
Resource rent	6,037	8,019	6,887
Employment	16	11	14
Total (Thousands)			
Harvest weight (mt)	175	78	254
Gross earnings (USD 2009)	367,129	119,073	486,202
Capital	367,129	119,073	486,202
Labor cost	99,465	38,335	137,800
Other variable expenses	54,866	653	55,519
Fixed expenses	55,069	5,954	61,023
EBITDA	157,728	74,132	231,860
Net profit	50,995	13,440	64,436
Capital cost	58,653	19,023	77,676
Depreciation	36,713	11,907	48,620
Opportunity cost	108,386	38,191	146,577
Net economic benefit	112,095	62,369	174,464
Resource rent	38,669	38,554	77,223
Employment	102	53	156

Notes: 1. See Table 10a for definitions.
2. Investment case assumptions are shown in Appendix C.

Source: Study.

Table 11
Ghana Artisanal Marine Sector Total Net Economic
Benefit for the Base, Investment, and Case Difference

Measure	Power Source Category		
	Motorized	Non-Motorized	Total
NPV Investment Case			
Net economic benefits ($000 2009 USD)	1,729,660	962,372	2,692,032
Resource rent ($000 2009 USD)	596,676	594,904	1,191,580
Distribution of benefits ($000 2009 USD)			
Returns to labor	1,534,783	591,520	2,126,303
Returns to owners	2,433,796	1,143,882	3,577,678
Transfers to government (license fees)	20,508	6,652	27,160
NPV Base Case			
Net economic benefits ($000 2009 USD)	1,504,652	837,179	2,341,831
Resource rent ($000 2009 USD)	519,056	517,514	1,036,570
Distribution of benefits ($000 2009 USD)			
Returns to labor	1,335,126	514,570	1,849,697
Returns to owners	2,117,188	995,077	3,112,265
Transfers to government (license fees)	0	0	0
Net Benefit (Investment Minus Base Case)			
Net economic benefits ($000 2009 USD)	225,008	125,193	350,201
Resource rent ($000 2009 USD)	77,620	77,390	155,010
Distribution of benefits ($000 2009 USD)			
Returns to labor	199,657	76,950	276,607
Returns to owners	316,608	148,806	465,414
Transfers to government (license fees)	20,508	6,652	27,160

Notes: 1. The table measure is NPV of net economic benefits which is sometimes called economic rent. Net economic benefits includes depreciation cost, and opportunity cost of labor and capital. The opportunity cost of labor is based on alternative livelihood choice for skipper/crew members.
2. The distribution of net economic benefits is among three groups: incomes to skipper/crew; net income to hull, motor, gear and other owners; and, net transfers to government. Taxes on sector profits are not included.

Source: Study.

Table 12
Ghana Artisanal Marine Sector Net Benefit Sensitivity to Discount Rate for Base Case

		Power Category		
		Motorized Canoe	Non-Motor. Canoe	Total
Net Benefit (thousands)				
Discount rate	5%	1,504,652	837,179	2,341,831
	10%	967,359	538,233	1,505,592
	20%	539,450	300,147	839,597

Notes: 1. Amounts are in thousands of USD 2009 real.
Source: Study.

Table 13
Ghana Artisanal Marine Sector Per Vessel Asset Value
Result's Sensitivity to Financial Parameters for Base Case

		Loan Terms	
		10 Years/0%	20 Years/15%
Asset value lower estimate			
Discount rate	5%	114,847	78,778
	10%	70,674	48,555
	20%	37,470	25,788
Asset value upper estimate			
Discount rate	5%	199,083	163,014
	10%	122,593	100,474
	20%	65,045	53,363

Notes: 1. The algorithm for asset value upper estimate includes 50 percent probability skipper/crew labor is expected in future revenue stream. The algorithm for asset value lower estimate assumes future revenue stream is only net profit to owners.
2. Asset value is weighted average over canoe power source categories.
3. Cost of capital is assumed to be annual amortization payments. While loan terms may be finite, it would be expected that a new loan for replacement would be needed at the payoff for the initial loan. This means the annual cost of capital would be an expected liability for every year in the future revenue stream.

Source: Study.

Table 14
Ghana Artisanal Marine Sector Resource Rent Total and Per Vessel for Base and Investment Cases

	Years Projected From Initial Conditions							NPV	
Cases	0	5	10	15	20	25	30	Total	Per Vessel
Base Case									
Motorized	35,014	38,541	35,453	30,548	28,175	26,824	25,987	519,056	71,519
Non-motorized	34,910	38,426	35,348	30,457	28,091	26,744	25,910	517,514	94,991
Total	69,923	76,967	70,801	61,005	56,267	53,568	51,898	1,036,570	81,583
Investment Case									
Motorized	35,014	37,341	38,669	39,657	39,832	39,873	39,877	596,676	93,158
Non-motorized	34,910	37,230	38,554	39,539	39,714	39,755	39,758	594,904	123,732
Total	69,923	74,572	77,223	79,197	79,546	79,628	79,635	1,191,580	106,268

Notes: 1. Amounts are in thousands of USD 2009 real, except NPV per vessel. Numbers in parenthesis are negative.
2. Year 0 is initial conditions.
3. Base and investment case assumptions shown in Appendix C.

Source: Study.

Table 15
Ghana Artisanal Marine Sector Per Vessel Resource Rent Sensitivity to Discount Rate for Base Case

		Power Category		
		Motorized Canoe	Non-Motor. Canoe	Total
Resource Rent Per Vessel				
Discount rate	5%	71,519	94,991	81,583
	10%	46,762	62,110	53,343
	20%	26,740	35,516	30,503

Notes: 1. Amounts are in USD 2009 real.
Source: Study.

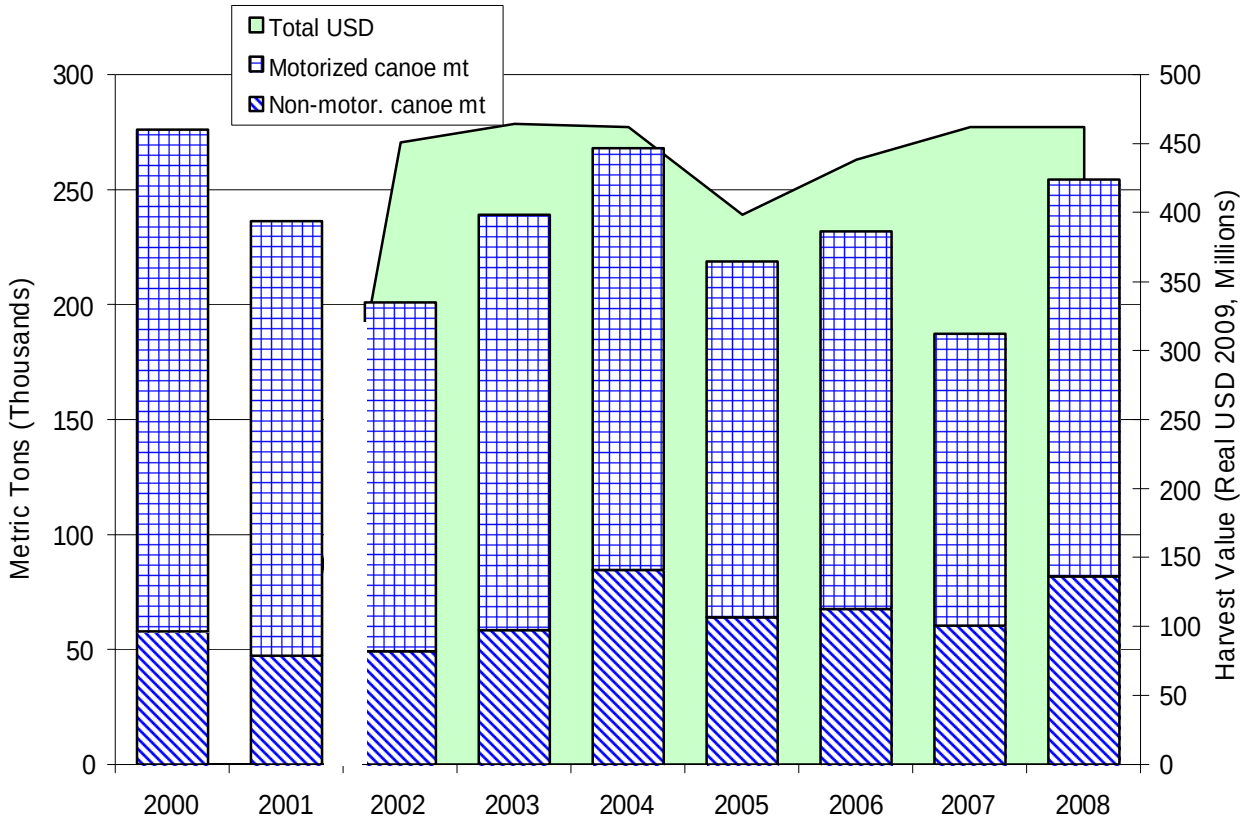
Table 16
Ghana Artisanal Marine Fishery Maximum Economic Yield Resource Rent for Base Case

		Static				Resource Rent	
		Year 0		Year 30			
	Reduction	Vessels	Resource Rent	Vessels	Resource Rent	Dynamic NPV	Percent Difference
Base case		11,213	69,923	13,381	51,898	1,036,570	
Maximum Economic Yield							
Imposed Year 6	49.33%	11,213	69,923	5,681	89,091	1,167,070	12.6%
Staged 25 year	2.679%	11,213	69,923	5,687	85,118	1,172,971	13.2%

Notes: 1. Amounts are in USD 2009 real, and resource rent is in thousands.
2. Imposed Year 6 assumes no effort change for Years 1 to 5, then all reduction in Year 6, then no change to Year 30. Staged 25 year assumes no effort change for Years 1 to 5, then reduces effort by the shown percent each year starting with Year 6. Other vessel sectors with fisheries in common with artisanal marine are assumed reduced by comparable amounts.

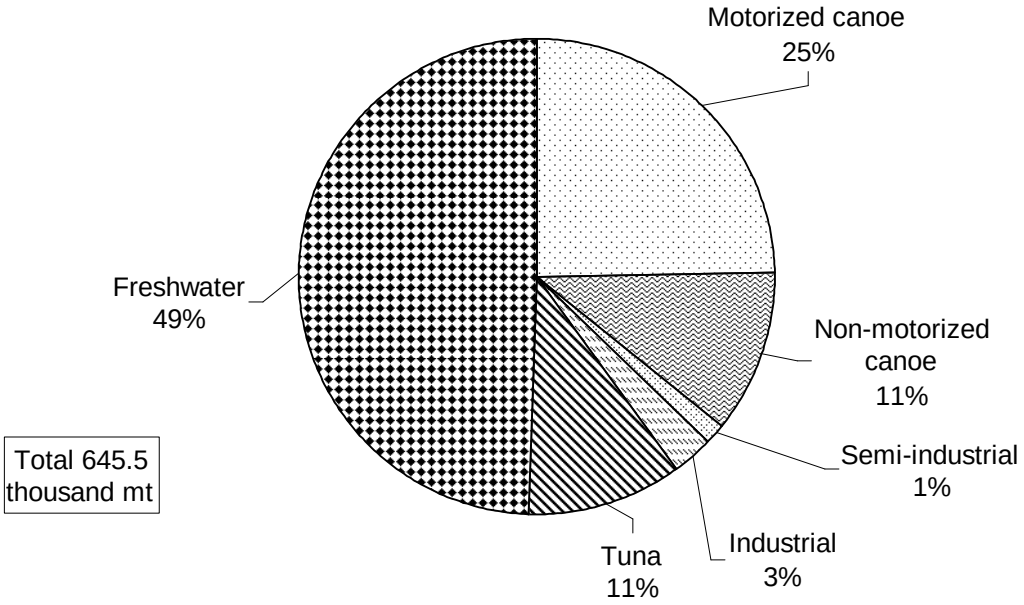
Source: Study.

Figure 1
Ghana Artisanal Marine Sector Landings in 2000 to 2008



Source: See Table 6 for notes and sources.

Figure 2
Ghana Capture Fisheries Landed Catch (Thousands) by Sector for Initial Conditions



Source: See Table 6 for notes and sources.

Figure 3
Ghana Artisanal Marine Sector Vessel Counts in 2000 to 2008

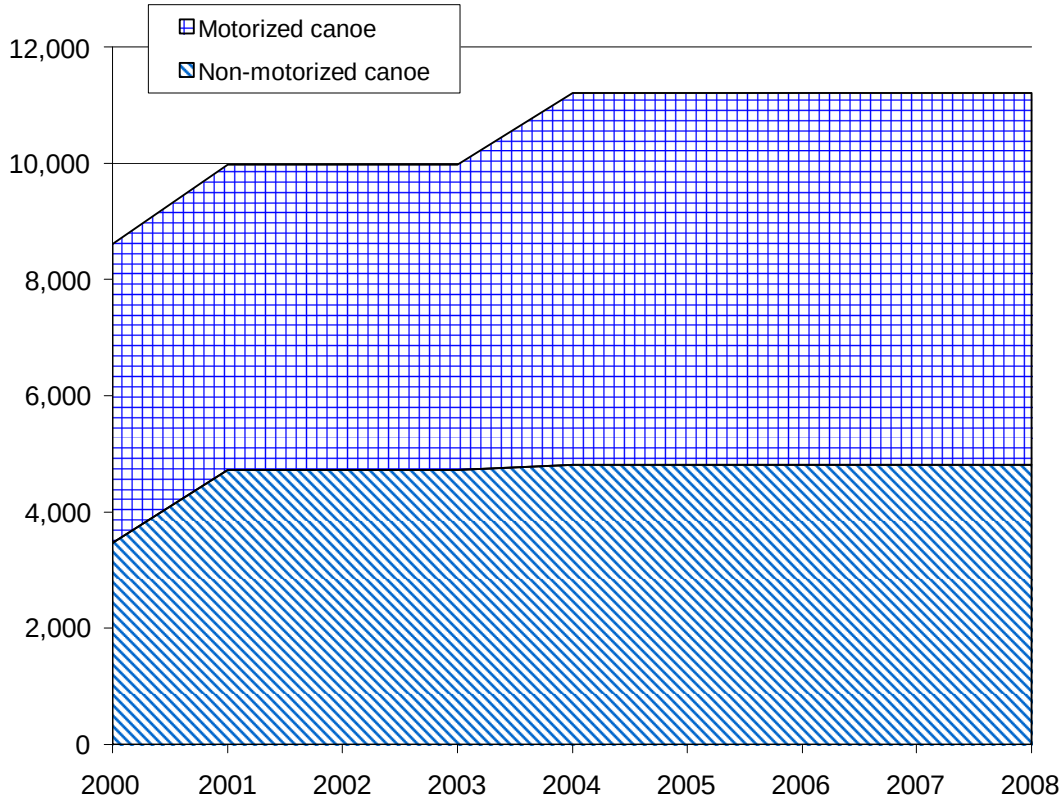
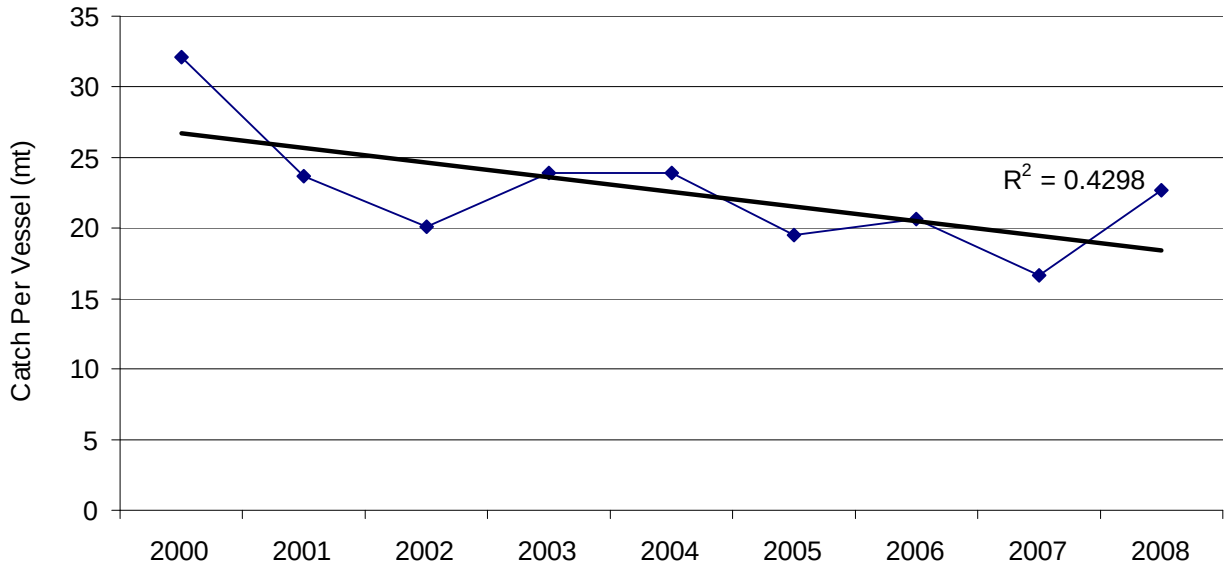
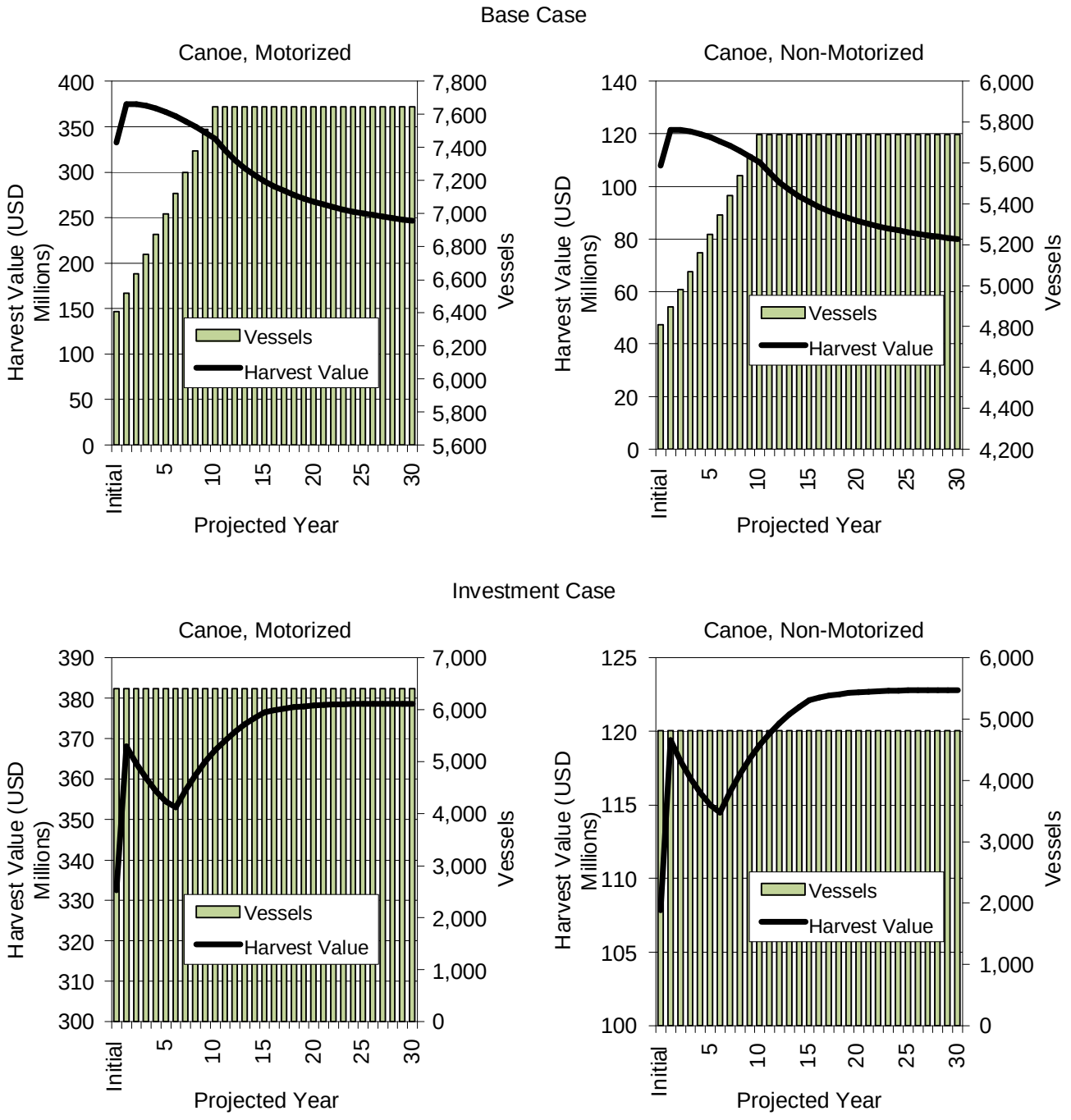


Figure 4
Ghana Artisanal Marine Sector Catch Per Vessel From 2000 Through 2008



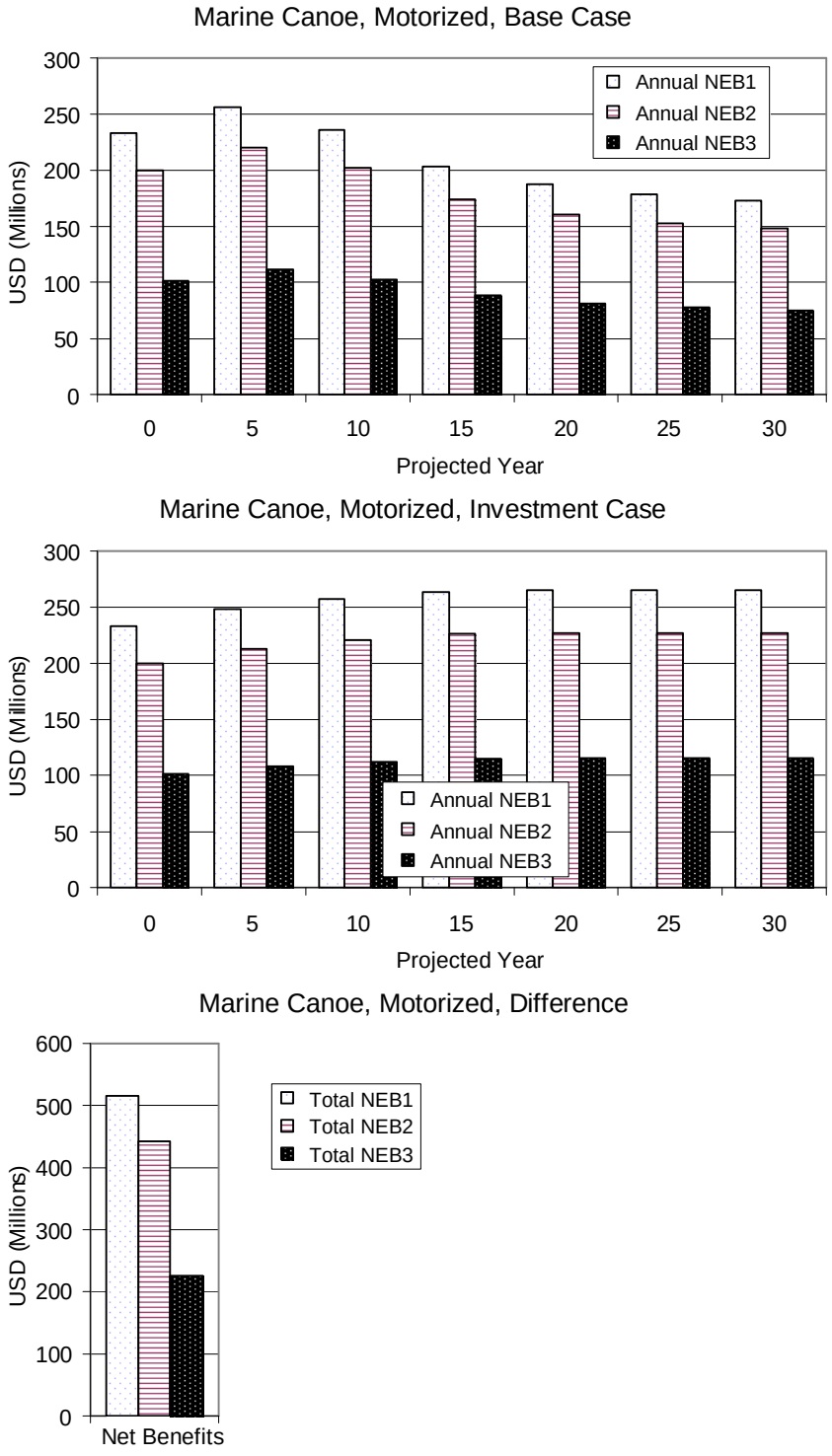
Source: See Table 6 for notes and sources.

Figure 5
Ghana Artisanal Marine Sector Landed Value and Vessel Counts
by Canoe Power Source Category for 30 Year Projections



Source: See Table 6 for notes and sources.

Figure 6
Ghana Artisanal Marine Sector Total Net Economic Benefit for the Base, Investment, and Case Difference

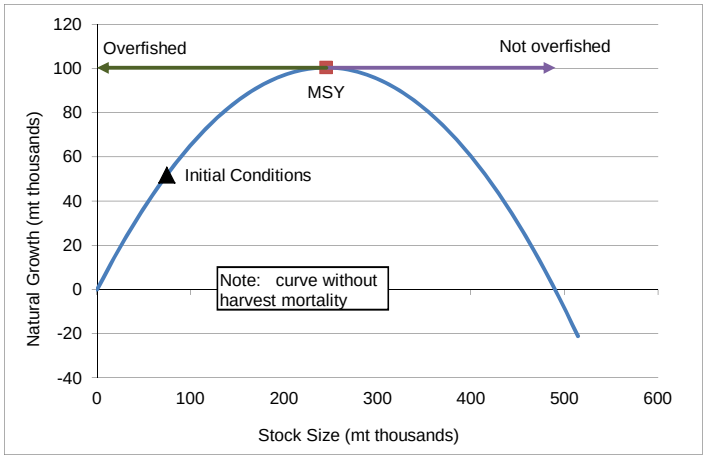


APPENDIX A

Maximum Sustainable Yield Curves

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Small pelagic

Biological Growth Curve



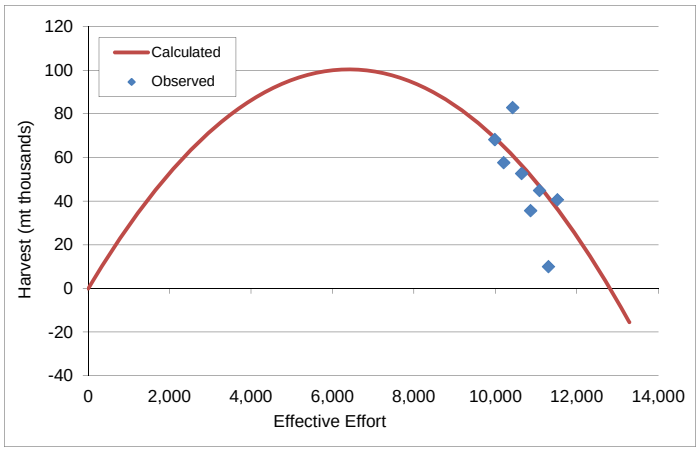
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.82	X	245,000	SSE	8,287
K	490,000	Y	100,450	R^2	0.55
q	0.000064	E eff	6,406	Sum diff.	36,439

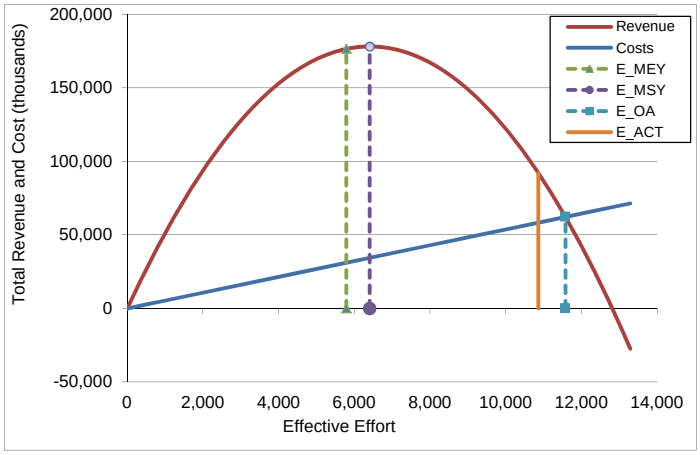
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	5,787	99.5	176,685	30,532	5,382	5,382	145,537
E_{MSY}	6,406	100.5	178,352	27,840	0	5,382	143,870
E_{OA}	11,574	35.1	62,297	5,382		5,382	0
E_{ACTUAL}	10,861	51.9	92,110	8,481		5,382	33,651

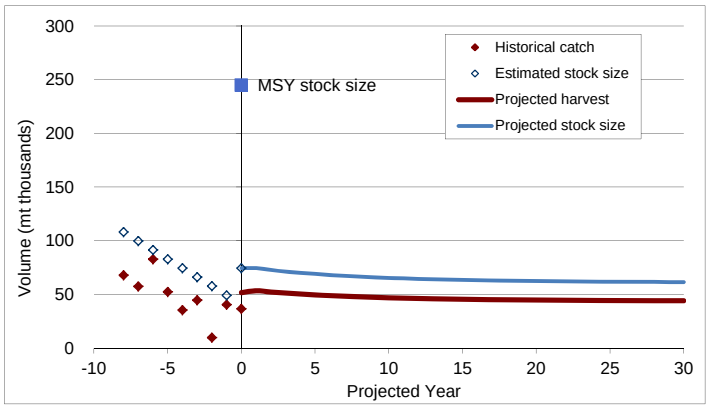
Biological Sustainable Yield Curve



Economic Sustainable Yield Curve

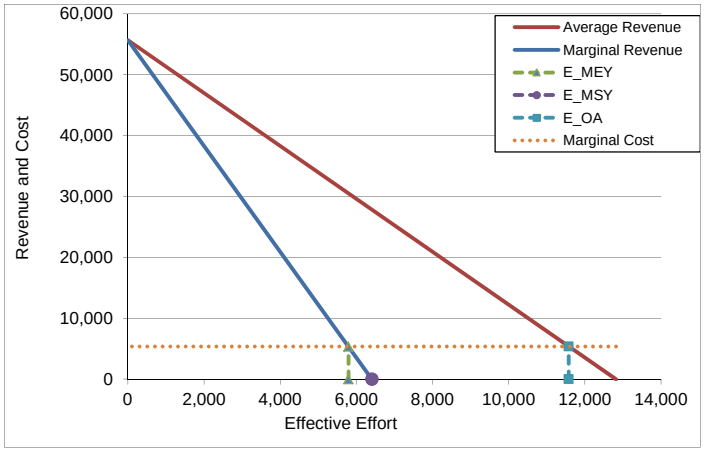


Stock Size and Harvest Projection



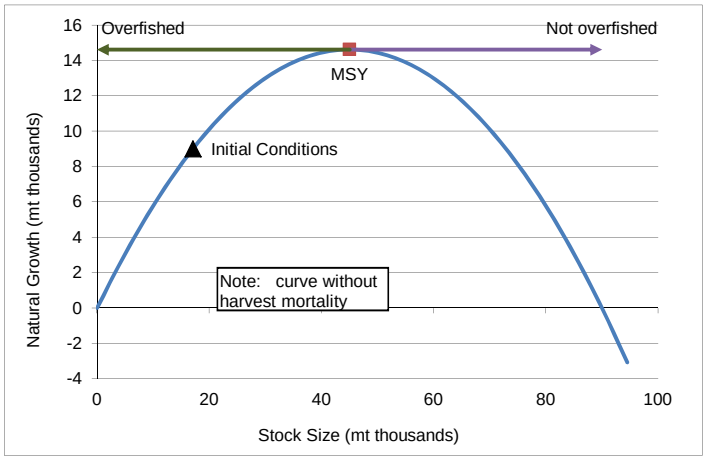
Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Marginal and Average Revenue and Cost Curves



Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Medium/large pelagic

Biological Growth Curve



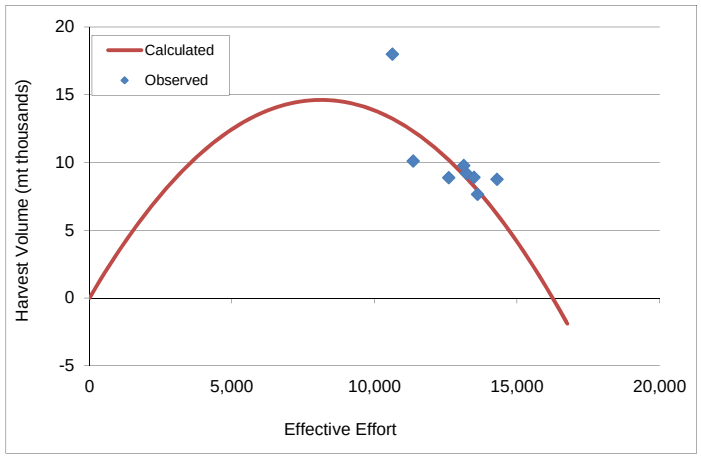
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.65	X	45,000	SSE	1,693
K	90,000	Y	14,625	R^2	0.55
q	0.000040	E eff	8,125	Sum diff.	(5,123)

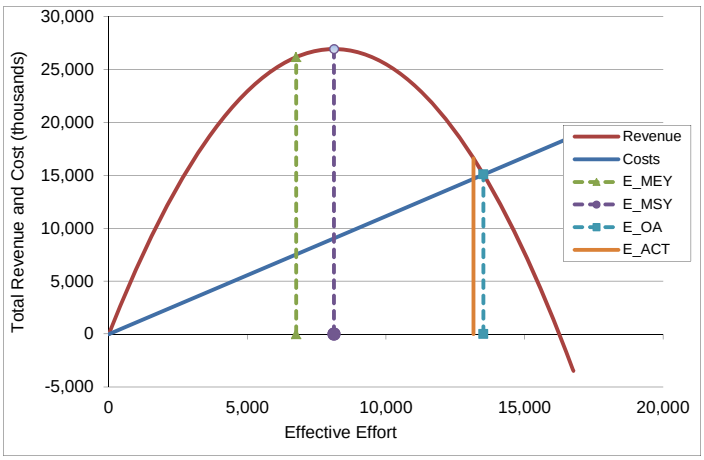
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	6,759	14.2	26,173	3,872	1,115	1,115	18,638
E_{MSY}	8,125	14.6	26,934	3,315	0	1,115	17,876
E_{OA}	13,517	8.2	15,070	1,115		1,115	0
E_{ACTUAL}	13,159	9.0	16,595	1,261		1,115	1,924

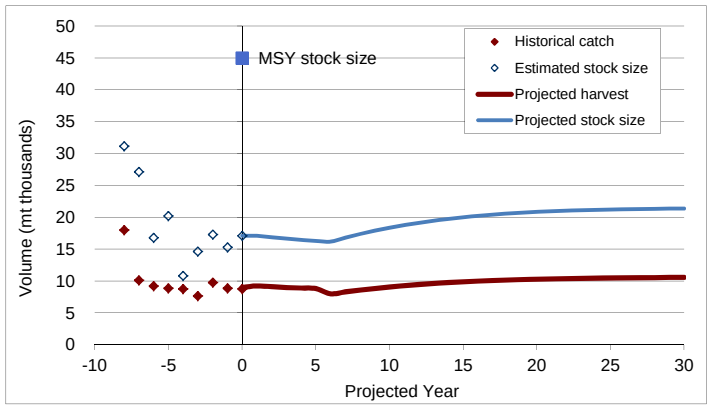
Biological Sustainable Yield Curve



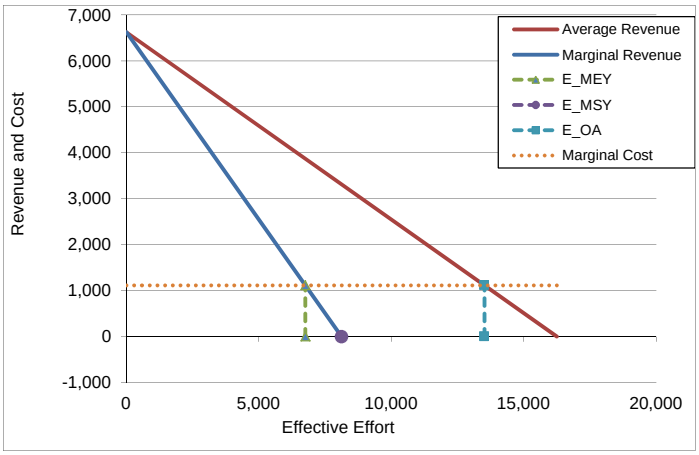
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



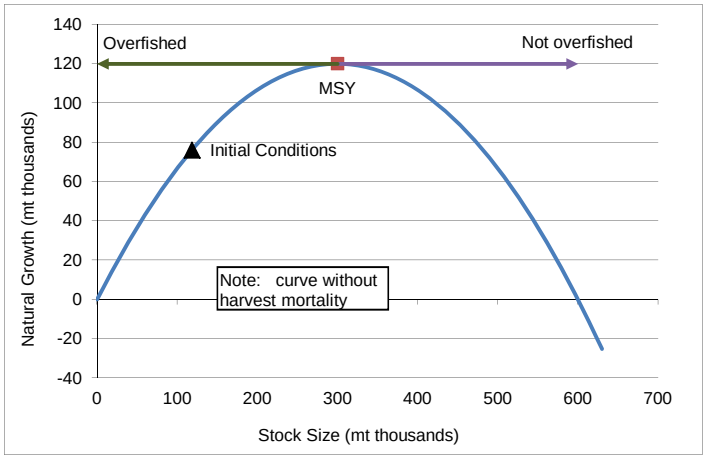
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Migratory pelagic

Biological Growth Curve



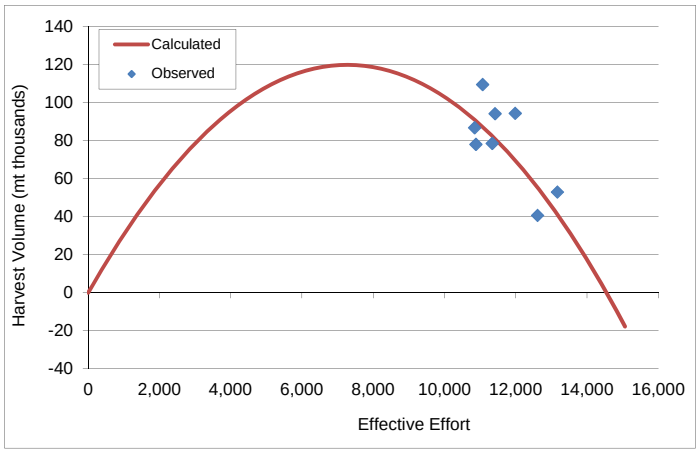
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.8	X	300,000	SSE	13,212
K	600,000	Y	120,000	R^2	0.54
q	0.000055	E eff	7,273	Sum diff.	(36,626)

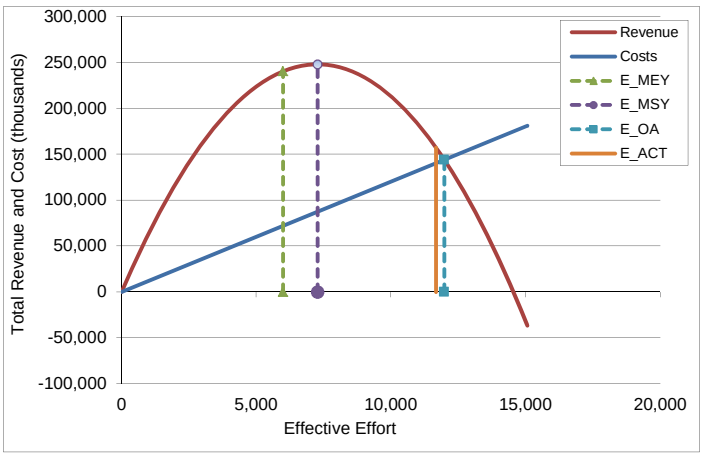
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	5,991	116.3	240,200	40,095	12,017	12,017	168,207
E_{MSY}	7,273	120.0	247,903	34,087	0	12,017	160,504
E_{OA}	11,981	69.7	143,985	12,017		12,017	0
E_{ACTUAL}	11,672	76.1	157,174	13,465		12,017	16,902

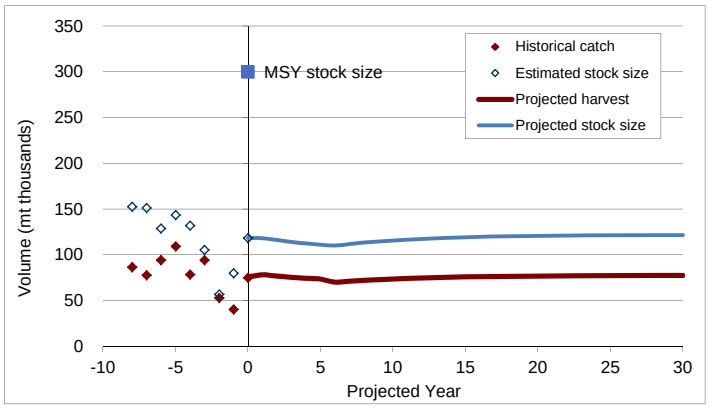
Biological Sustainable Yield Curve



Economic Sustainable Yield Curve

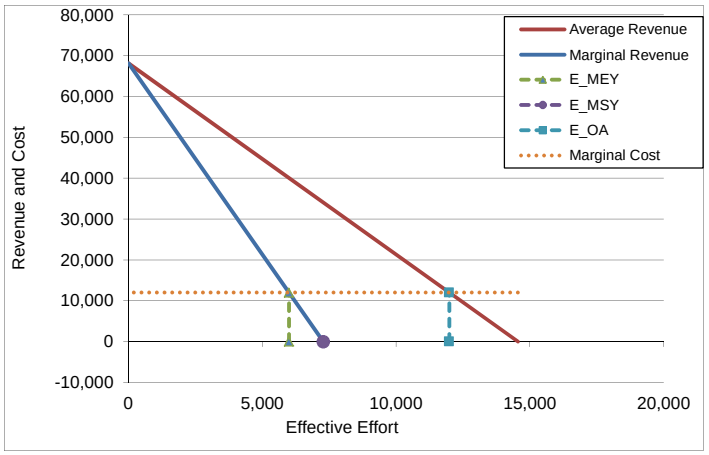


Stock Size and Harvest Projection



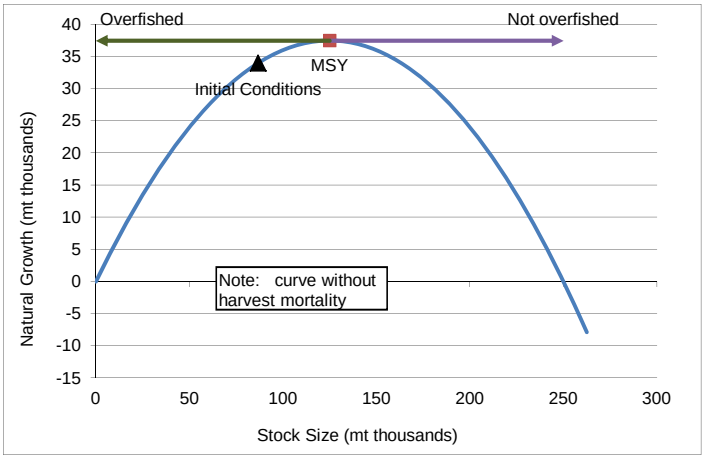
Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Marginal and Average Revenue and Cost Curves



Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Demersal

Biological Growth Curve



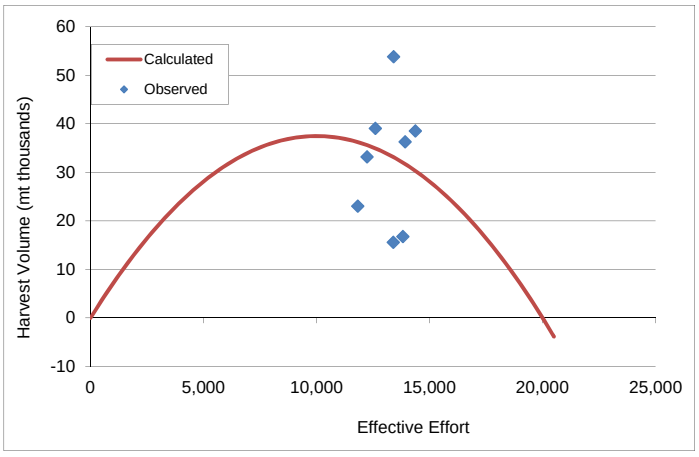
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.6	X	125,000	SSE	2,208
K	250,000	Y	37,500	R^2	0.01
q	0.000030	E eff	10,000	Sum diff.	10,994

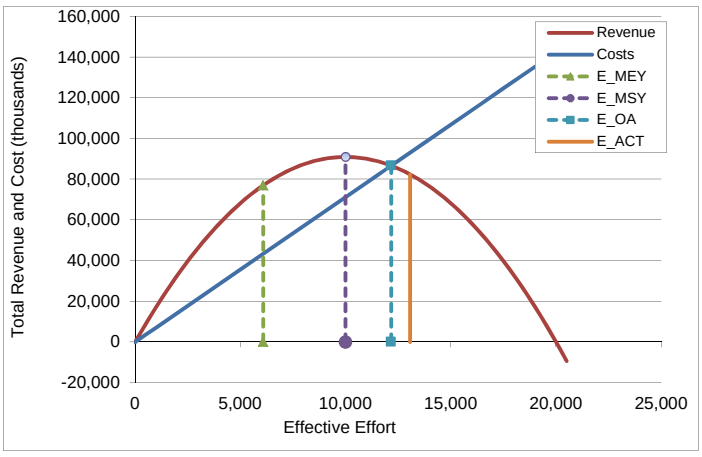
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	6,084	31.8	77,011	12,657	7,123	7,123	33,671
E_{MSY}	10,000	37.5	90,956	9,096	0	7,123	19,726
E_{OA}	12,169	35.7	86,678	7,123		7,123	0
E_{ACTUAL}	13,062	34.0	82,429	6,311		7,123	-10,612

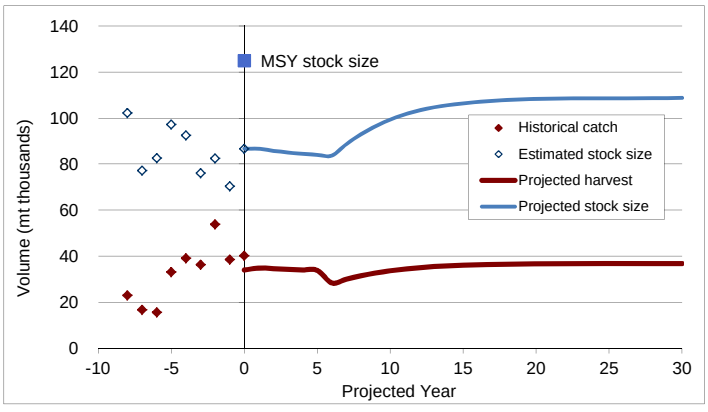
Biological Sustainable Yield Curve



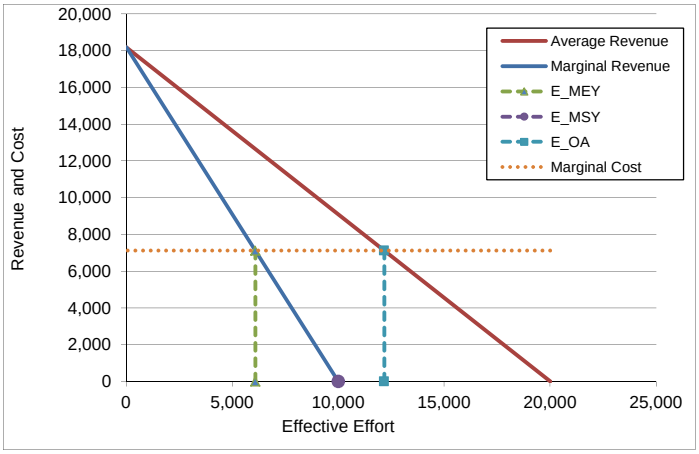
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



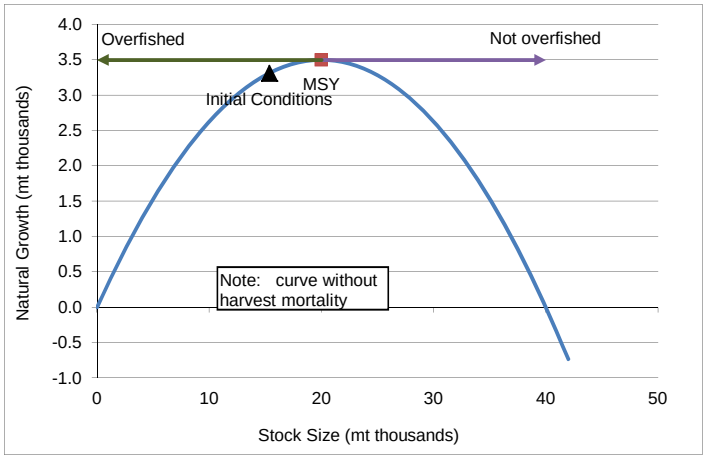
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Cephalopod

Biological Growth Curve



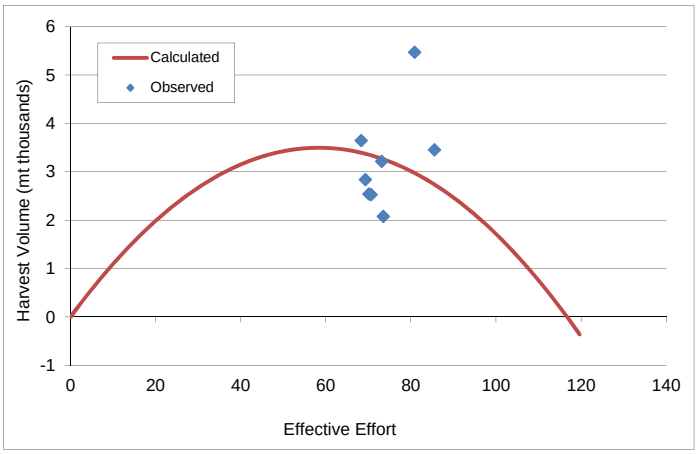
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.35	X	20,000	SSE	218
K	40,000	Y	3,500	R^2	0.26
q	0.003000	E eff	58	Sum diff.	(39)

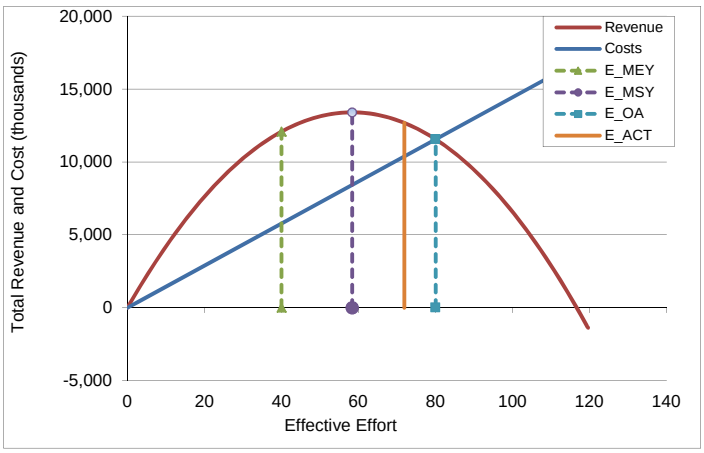
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	40	3.2	12,094	302,253	144,477	144,477	6,313
E_{MSY}	58	3.5	13,418	230,014	0	144,477	4,990
E_{OA}	80	3.0	11,562	144,477		144,477	0
E_{ACTUAL}	72	3.3	12,695	176,625		144,477	2,311

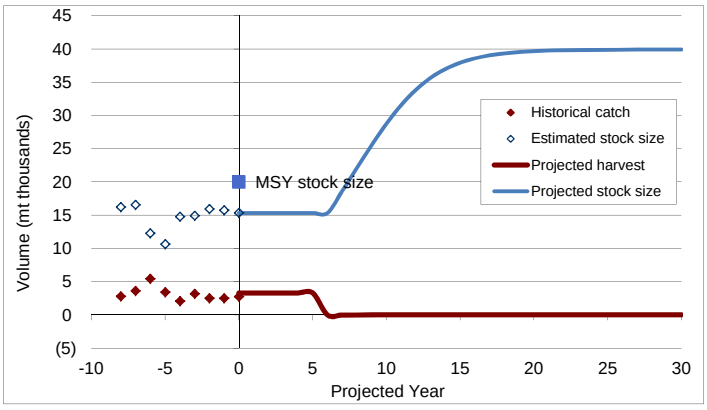
Biological Sustainable Yield Curve



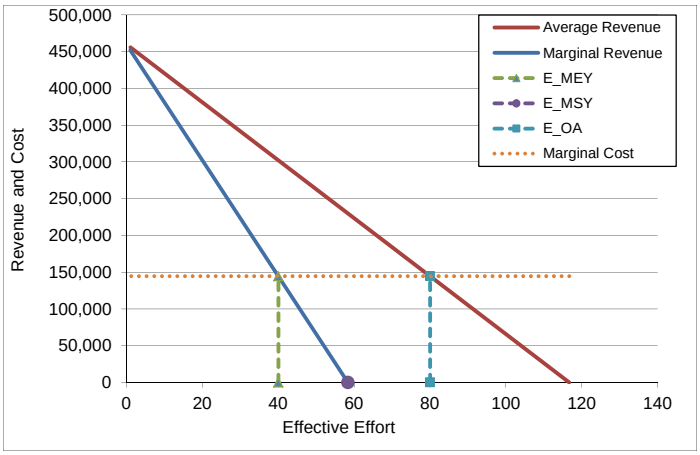
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



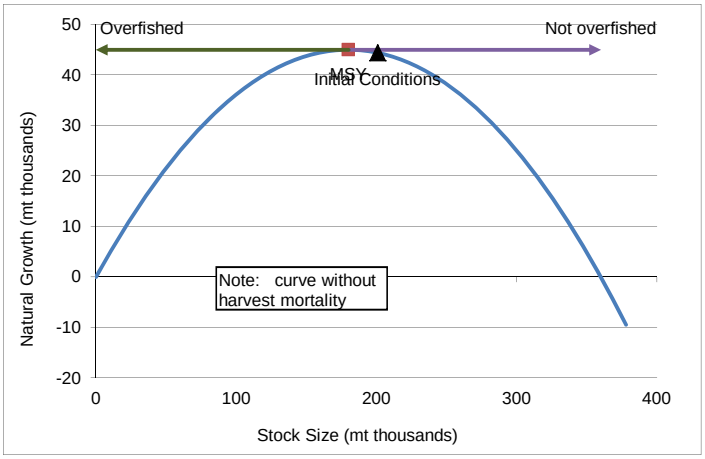
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Small tuna

Biological Growth Curve



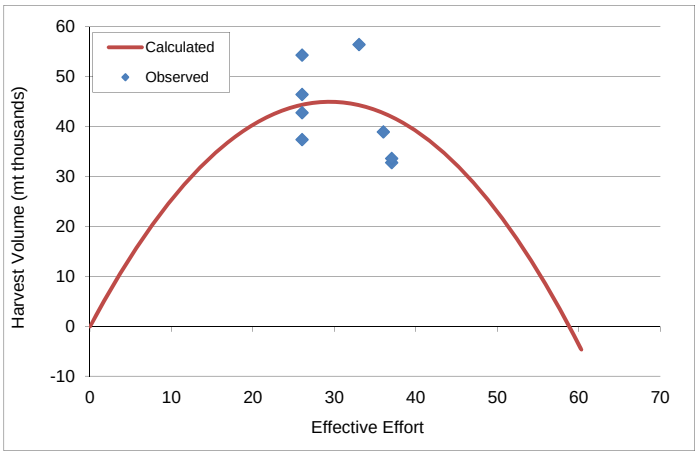
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.5	X	180,000	SSE	829
K	360,000	Y	45,000	R^2	0.54
q	0.008500	E eff	29	Sum diff.	6,028

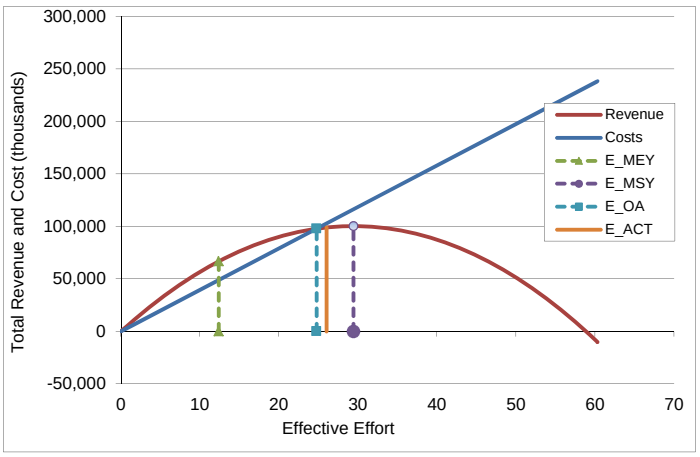
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	12	29.9	66,670	5,387,521	3,952,170	3,952,170	17,762
E_{MSY}	29	45.0	100,336	3,411,436	0	3,952,170	-15,904
E_{OA}	25	43.9	97,815	3,952,170		3,952,170	0
E_{ACTUAL}	26	44.4	98,986	3,807,163		3,952,170	-3,770

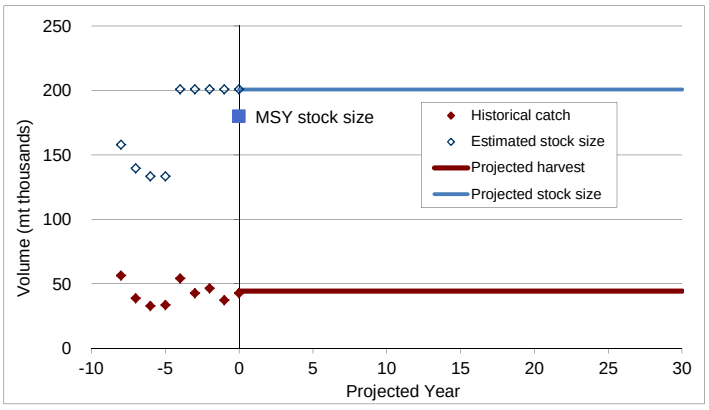
Biological Sustainable Yield Curve



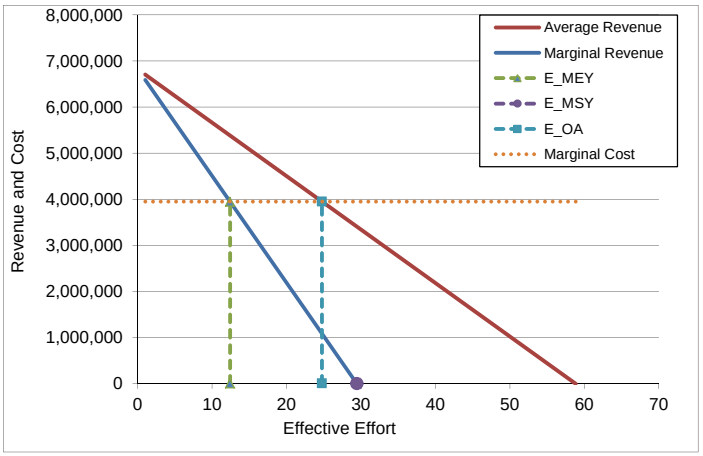
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



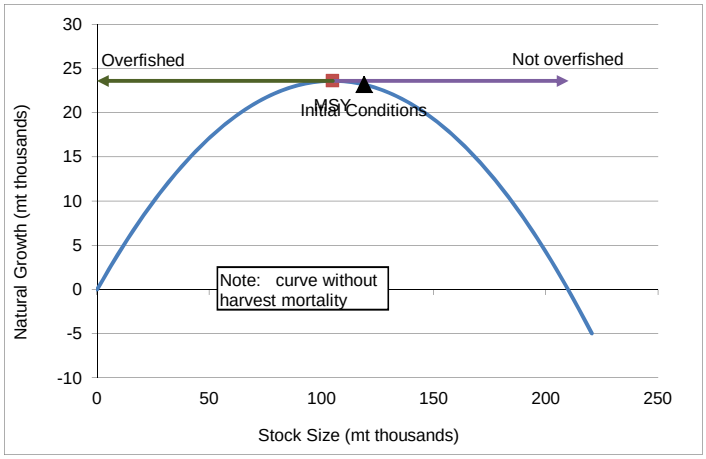
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Large tuna

Biological Growth Curve



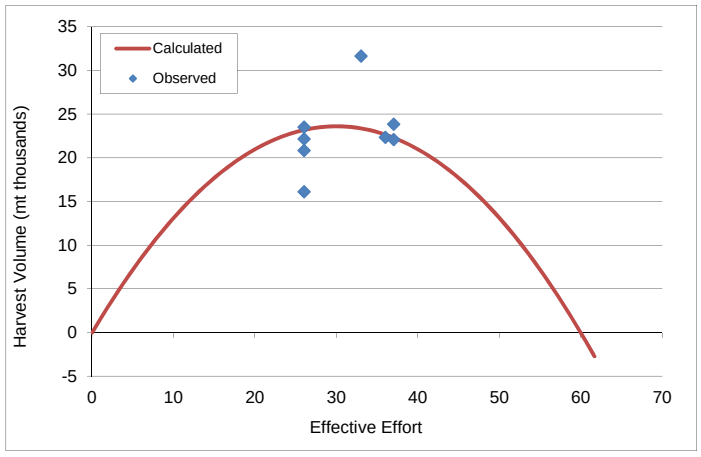
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.45	X	105,000	SSE	457
K	210,000	Y	23,625	R^2	0.02
q	0.007500	E eff	30	Sum diff.	955

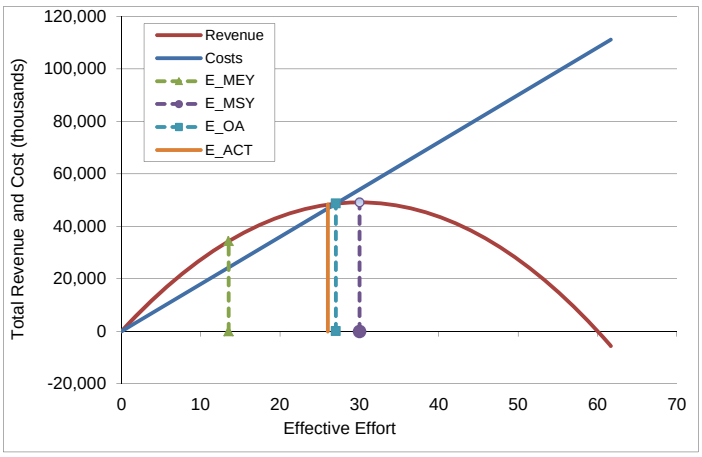
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	14	16.5	34,329	2,540,701	1,802,245	1,802,245	9,978
E_{MSY}	30	23.6	49,187	1,639,579	0	1,802,245	-4,880
E_{OA}	27	23.4	48,703	1,802,245		1,802,245	0
E_{ACTUAL}	26	23.2	48,313	1,858,189		1,802,245	1,455

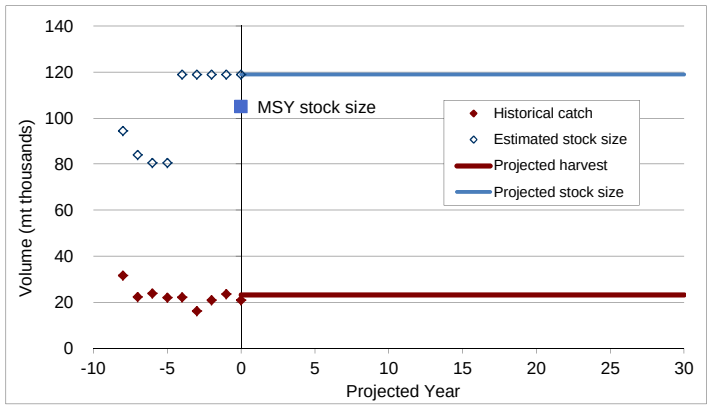
Biological Sustainable Yield Curve



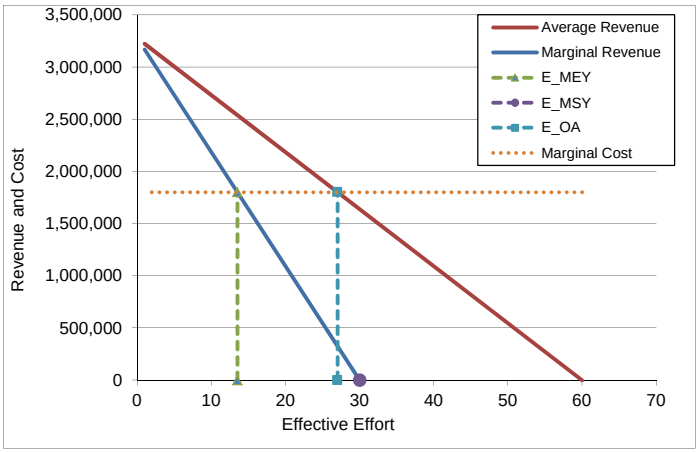
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



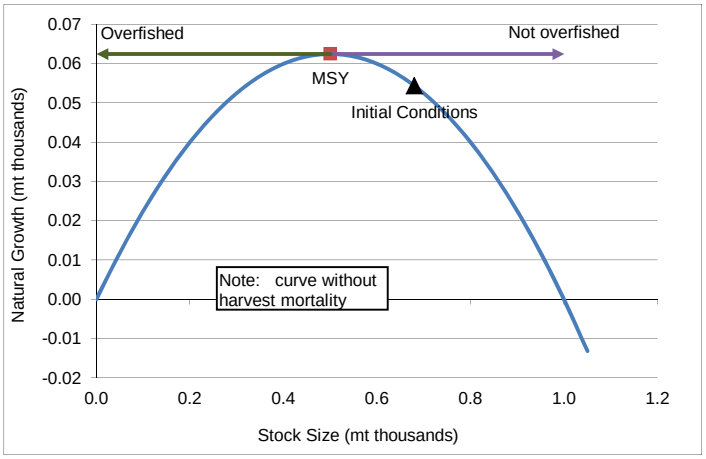
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Shrimp

Biological Growth Curve



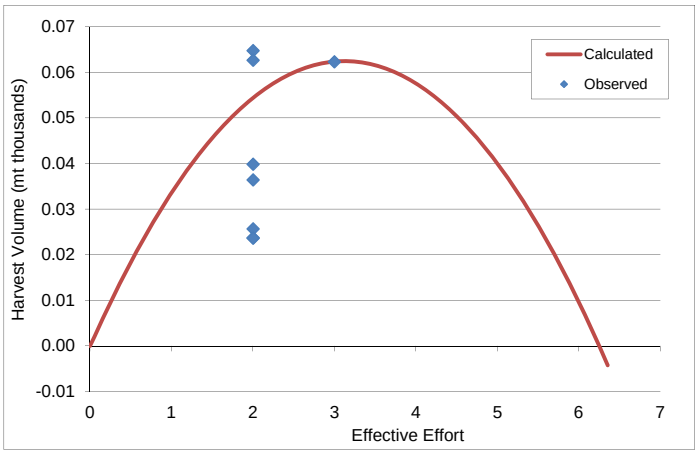
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.25	X	500	SSE	3
K	1,000	Y	63	R^2	0.20
q	0.040000	E eff	3	Sum diff.	104

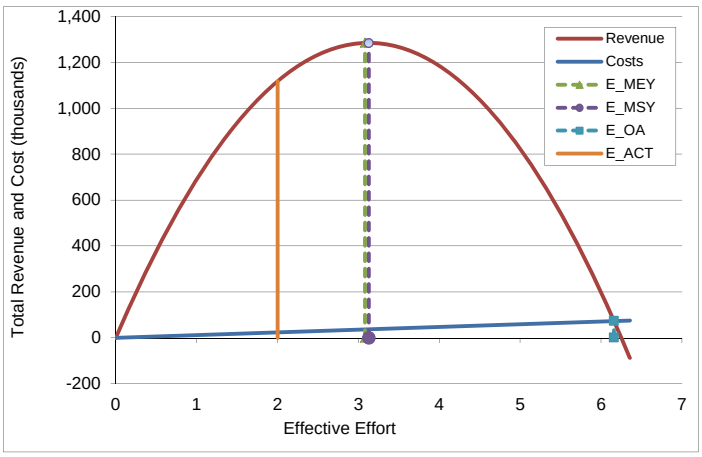
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	3	0.1	1,285	417,208	11,932	11,932	1,248
E_{MSY}	3	0.1	1,285	411,242	0	11,932	1,248
E_{OA}	6	0.0	73	11,932		11,932	0
E_{ACTUAL}	2	0.1	1,119	559,289		11,932	1,095

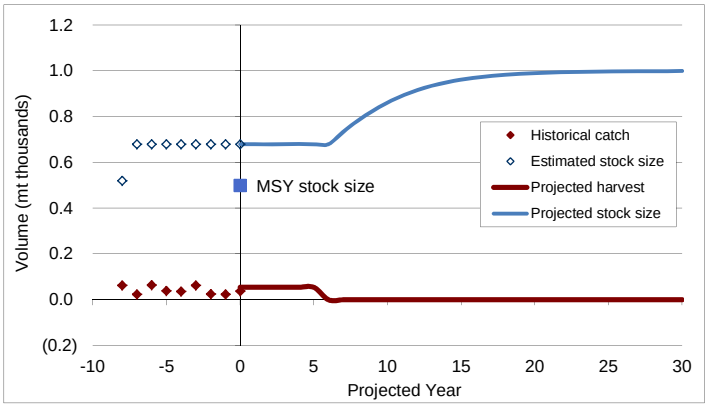
Biological Sustainable Yield Curve



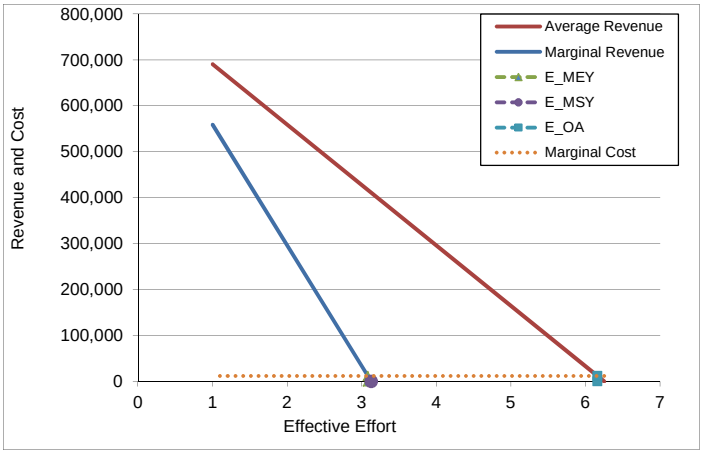
Economic Sustainable Yield Curve



Stock Size and Harvest Projection



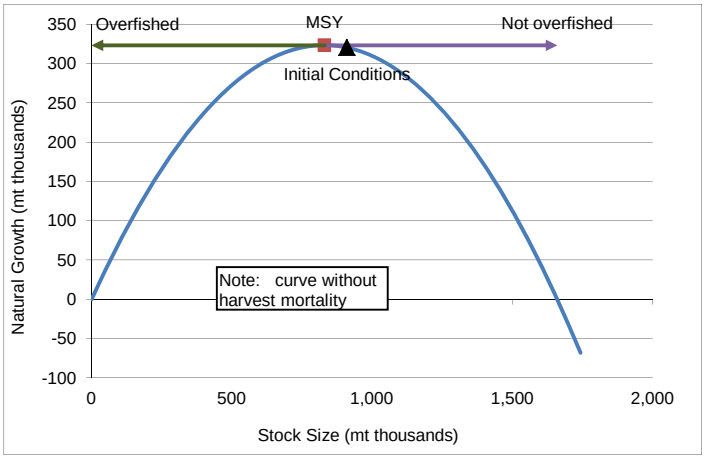
Marginal and Average Revenue and Cost Curves



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Fish Model Sectors
Case: Investment New 1
Date: June 29, 2011, Ver. 6
Fishery: Freshwater

Biological Growth Curve



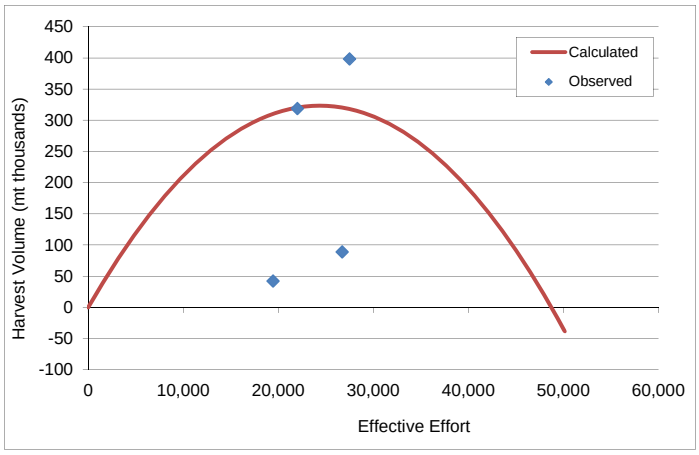
Biological Sustainable Yield Parameters and Goodness of Fit Statistics

Equation Parameters		MSY Results		Harvest Estimation	
r	0.78	X	830,000	SSE	5,094
K	1,660,000	Y	323,700	R^2	0.27
q	0.000016	E eff	24,375	Sum diff.	421,731

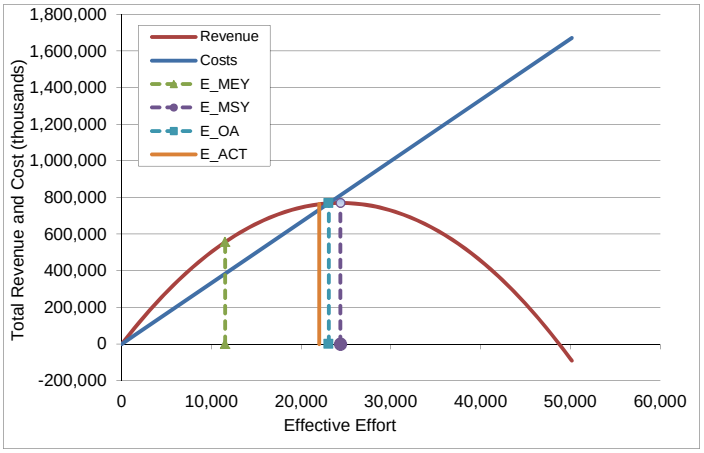
Economic Sustainable Yield Relationships

Measure	Effective Effort	Harvest (000)	Revenue ($000)	Average Revenue	Marginal Revenue	Marginal Cost	Economic Rent ($000)
E_{MEY}	11,530	233.8	557,181	48,323	33,353	33,353	172,610
E_{MSY}	24,375	323.7	771,386	31,647	0	33,353	-41,595
E_{OA}	23,061	322.8	769,143	33,353		33,353	0
E_{ACTUAL}	22,008	320.6	764,112	34,720		33,353	30,077

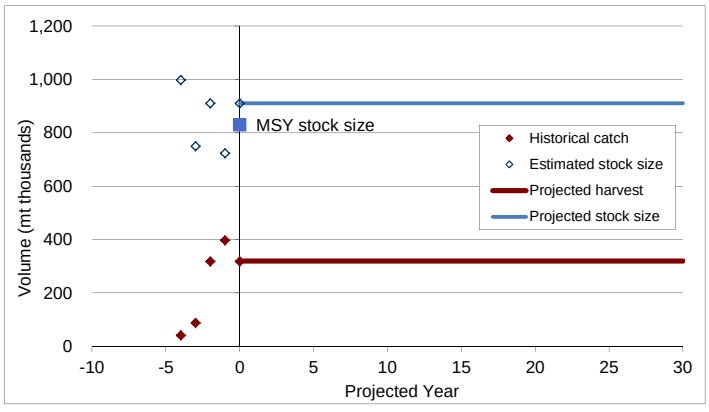
Biological Sustainable Yield Curve



Economic Sustainable Yield Curve

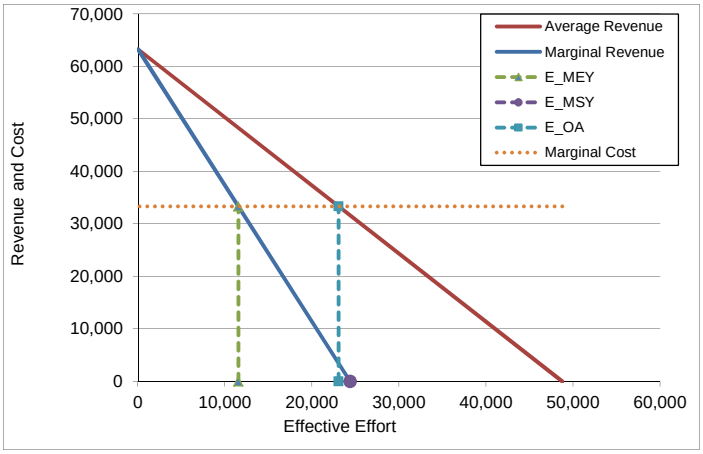


Stock Size and Harvest Projection



Note: 1. Year zero (initial conditions) for the projections will have discontinuities from historical data series because assumptions (such as trend estimating) and averaging were used to derive year zero measures.

Marginal and Average Revenue and Cost Curves

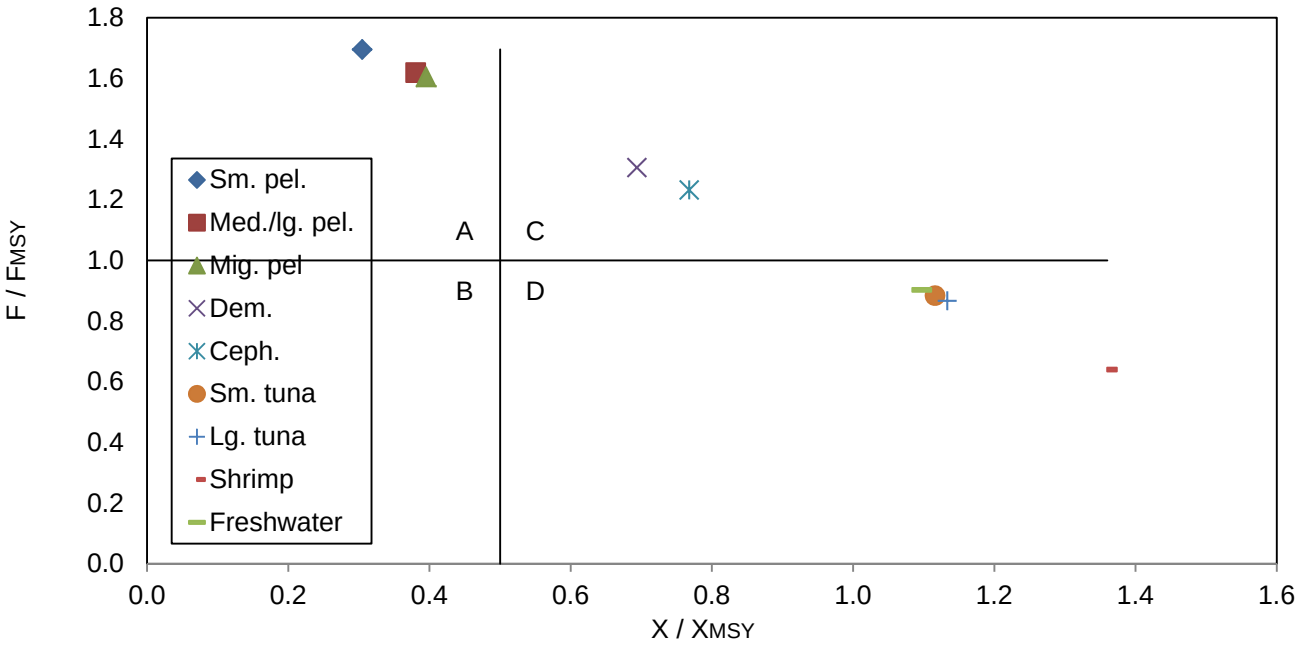


APPENDIX B

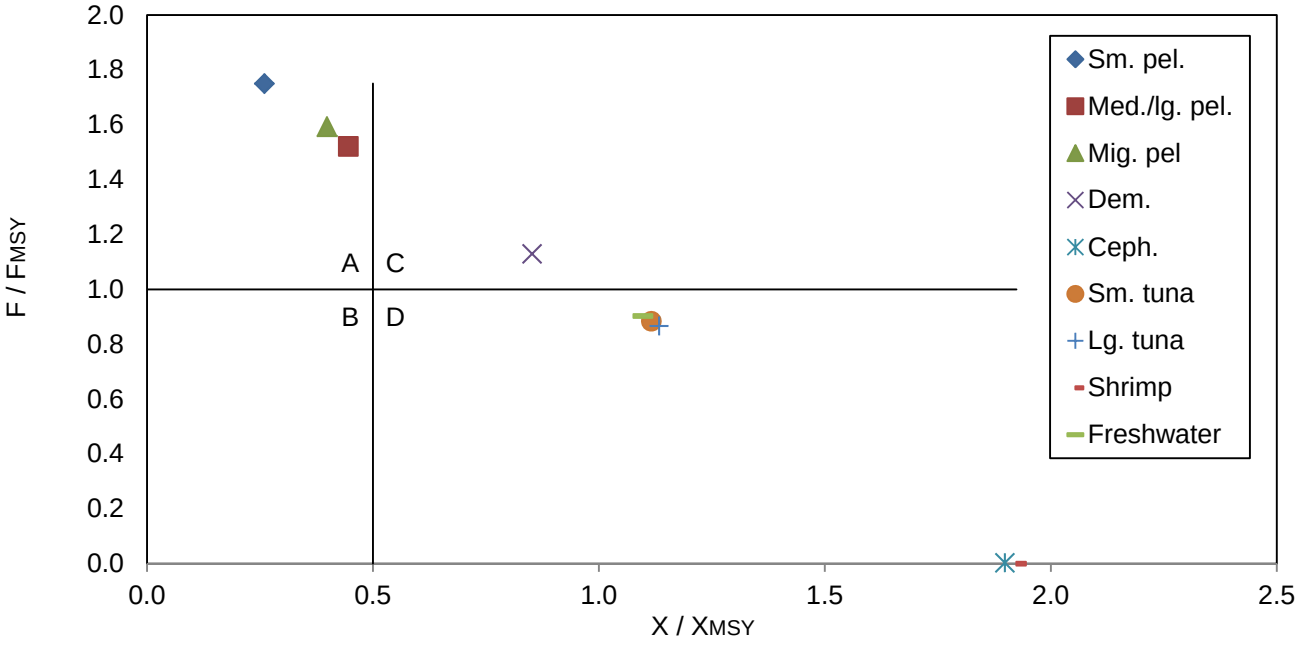
Overfishing/Overfished Stock Determination Status

Project: West Africa Regional Fisheries Program
Country: Ghana
Statement: Stock Status Determination
Case: Investment New 1
Date: June 29, 2011, Ver. 6

Stock Status Determination for Initial Conditions



Stock Status Determination for Year 15



Notes: 1. Vertical and horizontal lines correspond to biological determinates for maximum sustainable stock growth X_{MSY} (overfished status) given maximum sustainable fishing mortality F_{MSY} (overfishing status). The panel demarcations can be interpreted to be:
A: Overfishing is occurring; stock is overfished.
B: Overfishing is not occurring; stock is overfished.
C: Overfishing is occurring; stock is not overfished.
D: Overfishing is not occurring; stock is not overfished.

APPENDIX C

Ghana Model Inputs and Drivers

Ghana Model Inputs and Drivers

	Base	Investment
INPUTS		
Header Block		
Case	Base	Investment
Investment Strategy		
Investment amount (millions)	$0.00	$55.04
Loan share	100.0%	89.5%
Loan interest rate	0.0%	0.0%
O&M increase per year (millions)	$0	$5
Typical private interest rate	15%	15%
Typical private loan term (years)	20	20
Typical capital lifespan vessel and facilities	10	10
Discount rate	5.0%	5.0%
Labor Opportunity		
Labor cost probability	50%	50%
Wage (hourly)	$3.00	$3.00
Fishery Effort		
Canoe vessel	increase 200 vessels per year for 10 years, then no change	no change
Semi-industrial	decrease 3 vessels per year over 30 years	50% reduction in Year 6
Industrial	no change	100% reduction in Year 6
Tuna	no change	no change
Freshwater	increase 200 vessels per year for 10 years, then no change	no change
DRIVERS		
Finance and Government Policy Conditions		
Loan and grant drawdowns	1	5
Loan term (years)	30	30
Project horizon (years)	30	30
Import tariffs:	$2 million per year sequestered for fisheries and aquaculture	$2 million per year sequestered for fisheries and aquaculture programs
Harvest and processor licensing		
ad-valorem ex-vessel starting Year 6	0.0%	0.5%
Market and Production		
1. Marine Fisheries		
Harvest prices	no change	flat until Year 6, then increase by a total of 2% over 10 years then flat, except tuna no change
Canoe price differential	-20.0%	-20.0%
2. Freshwater fisheries		
Harvest prices	no change	flat until Year 6, then increase by a total of 2% over 10 years then flat
3. Processing		
Operations	no change, 0% for Year 6 increases in product recovery	increase recoveries by 3% starting Year 6, 3% for Year 6 increases in product recovery
Price	no change, 0% for Year 6 increases in economic yield	increase ex-processor sale price by 2% starting Year 6, 2% for Year 6 increases in economic yield
Post-harvest loss		
Smoker	20%	20%
Fresh	10%	10%
Frozen	10%	10%
Tuna	2.5%	2.5%
4. Aquaculture		
Variable cost	no change	decrease by 1% per year for 10 years then 1/2% per year
First sale price	flat until Year 10 then decrease by 1% per year	flat until Year 10 then decrease by 1% per year
Annual production increase (mt)	increase production by 1,000 mt per year for 30 years	increase production by 1,000 mt per year for 30 years
5. Trade		
Population growth per year	2.1%	2.1%
Tariff import rate (not incl. VAT)	5%	5%
Non-food utility rate	5%	5%

Source: Study.

APPENDIX D

Model Algorithms

Model Algorithms

Asset value is net present value of net profit stream in perpetuity considering assumed discount rate.

Harvest sector capital is assumed purchase price for hull, engine, gear, electronics, etc. The purchase price used a mix of survey information and rule-of-thumb approach for estimates.

Capital costs are amortization payments at current loan terms.

Benefit-cost analysis is the net present value of changed net economic benefits. Changed net economic benefits are future net economic benefits subtracted from initial conditions.

Operation and maintenance cost increases that would accompany investment strategies. An example would be the annual cost for operating enforcement vessels if vessel purchase was an investment strategy.

Gross earnings before interest, taxes, depreciation, and amortization (EBITDA); i.e. returns to owners who may be vessel motor, hull, and/or gear investors.

Total earnings are harvest value plus tendering or other non-fishing revenue.

Variable costs are labor and other costs related to fishing activities. Labor is captain and crew share of total earnings. Other variable includes fuel, ice, bait, and expendable gear, etc.

Fixed costs are annual costs that are incurred whether or not fishing occurs, such as for moorage, license fees, insurance, loan payments, etc.

Resource rent is total earnings minus total costs minus normal profit. Total costs are EBITDA plus labor minus depreciation minus opportunity cost minus normal profit.

Normal profit is expectations for returns to owners and labor considering business risk; 20 percent of total earnings was assumed for the study.

Economic rent is return to owners, i.e. total earnings less costs for fishing variable and annual fixed costs and less depreciation and opportunity labor and capital costs.

Transfers are taxes, and can also be fees if not accounted in fixed costs.

Depreciation is straight line at applicable life span with zero salvage value.

Opportunity cost is the probability that labor could have higher wages other than in fishing industry and capital investments could earn more if invested elsewhere.

Labor probability is the share of labor whose alternative livelihood income could be greater in other industries; 50 percent was assumed for the study.

Net economic benefits is the return to owner and labor. It is EBITDA plus labor minus depreciation minus opportunity cost.

Added value is measured at the wholesale level. It is the difference between processor sales and harvested value after considering post-harvest loss.

Processor revenue includes seafood product sales ready for national consumer and export sales; and non-recovery sales for non-food utilization like fish meal.

Processor share is post harvest loss as a share of harvests.

Sensitivity testing is for parameters subject to uncertainty, such as financial parameters like discount rate; and, biological parameters (for example, carrying capacity).

Employment is full-time equivalent assuming labor is wages/salaries and national minimum wage standards for initial conditions.

Surplus production model used Gordon-Schaefer function to estimate future harvests given assumptions about biomass intrinsic growth rate, environmental carrying capacity, and stock catchability.

Harvest yield is an assumed linear relationship between catchability, stock size, and effort.

Catchability is a measure of harvest efficiency affected by species characteristics, gear type, fishing strategies, etc.

Effort is proxied using sector vessel counts per year. This assumes that each vessel within a sector applies an average fishing pressure per trip and that each vessel makes the same number of trips per year.

Effective effort is used to make each vessel's fishing power homogenous within a defined fishery and across sectors.

Maximum sustainable yield is the amount of harvest (and the associated stock size) that maximizes long run equilibrium yield.

APPENDIX E

Model Results All Sectors Performance Indicators for the Base and Investment Cases

PERFORMANCE INDICATORS

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Number of vessels								
Marine								
Canoe	11,213	12,249	13,381	13,381	13,381	13,381	13,381	
Motorized	6,405	6,997	7,644	7,644	7,644	7,644	7,644	
Non-motorized	4,808	5,252	5,738	5,738	5,738	5,738	5,738	
Semi-industrial	240	225	212	199	187	175	165	
Industrial	72	72	72	72	72	72	72	
Tuna	26	26	26	26	26	26	26	
Freshwater	22,008	23,026	24,092	24,092	24,092	24,092	24,092	
Total	33,559	35,599	37,783	37,770	37,758	37,746	37,736	
Landed catch (000's mt)								
Marine								
Canoe	231.9	255.3	234.8	202.4	186.6	177.7	172.1	
Motorized	160.3	176.4	162.3	139.8	129.0	122.8	119.0	
Non-motorized	71.7	78.9	72.6	62.5	57.7	54.9	53.2	
Semi-industrial	8.0	6.6	4.9	3.7	3.1	2.7	2.4	
Industrial	17.6	18.0	17.2	16.7	16.5	16.4	16.3	
Tuna	68.9	71.8	71.8	71.8	71.8	71.8	71.8	
Freshwater	319.0	328.4	330.5	324.2	323.7	323.7	323.7	
Total	645.5	680.1	659.3	618.8	601.7	592.2	586.3	
Harvest value (000's)								
Marine								
Canoe	440,241	484,590	445,766	384,094	354,258	337,269	326,752	6,526,305
Motorized	332,424	365,912	336,596	290,027	267,498	254,670	246,728	4,927,980
Non-motorized	107,817	118,679	109,170	94,067	86,760	82,599	80,023	1,598,325
Semi-industrial	17,450	14,453	10,781	8,145	6,755	5,878	5,266	167,115
Industrial	71,438	72,929	69,882	67,638	66,733	66,327	66,139	1,076,367
Tuna	154,968	161,408	161,408	161,408	161,408	161,408	161,408	2,481,239
Freshwater	760,186	782,609	787,542	772,564	771,386	771,291	771,283	11,945,987
Total	1,444,284	1,515,989	1,475,380	1,393,849	1,360,541	1,342,173	1,330,847	22,197,013
Catch (mt) per vessel								
Marine								
Canoe	20.7	20.8	17.6	15.1	13.9	13.3	12.9	
Motorized	25.0	25.2	21.2	18.3	16.9	16.1	15.6	
Non-motorized	14.9	15.0	12.6	10.9	10.0	9.6	9.3	
Semi-industrial	33.3	29.4	23.3	18.8	16.6	15.4	14.7	
Industrial	244.8	249.9	239.4	231.7	228.6	227.2	226.6	
Tuna	2,651.3	2,761.5	2,761.5	2,761.5	2,761.5	2,761.5	2,761.5	
Freshwater	14.5	14.3	13.7	13.5	13.4	13.4	13.4	
Net economic benefits (000's)								
Marine								
Canoe								
Motorized	101,498	111,723	102,772	88,554	81,675	77,758	75,333	1,504,652
Non-motorized	56,473	62,162	57,182	49,271	45,443	43,264	41,915	837,179
Semi-industrial	4,147	3,202	2,007	1,176	784	570	444	31,901
Industrial	6,446	6,581	6,306	6,104	6,022	5,985	5,968	97,130
Tuna	34,994	37,377	37,377	37,377	37,377	37,377	37,377	574,580
Freshwater	232,106	238,953	240,459	235,886	235,526	235,497	235,494	3,647,448
Total	435,666	459,998	446,103	418,367	406,828	400,452	396,532	6,692,889

PERFORMANCE INDICATORS (CONT.)

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Depreciation (000's)								
Marine								
Canoe								
Motorized	33,242	36,591	33,660	29,003	26,750	25,467	24,673	492,798
Non-motorized	10,782	11,868	10,917	9,407	8,676	8,260	8,002	159,832
Semi-industrial	809	760	714	670	629	591	555	10,757
Industrial	7,144	7,293	6,988	6,764	6,673	6,633	6,614	107,637
Tuna	8,602	8,602	8,602	8,602	8,602	8,602	8,602	132,228
Freshwater	76,019	78,261	78,754	77,256	77,139	77,129	77,128	1,194,599
Total	136,597	143,374	139,634	131,701	128,469	126,681	125,574	2,097,851
Capital cost (000's)								
Marine								
Canoe								
Motorized	53,109	58,459	53,775	46,335	42,736	40,686	39,418	787,301
Non-motorized	17,225	18,960	17,441	15,028	13,861	13,196	12,785	255,351
Semi-industrial	1,293	1,214	1,140	1,070	1,005	944	886	17,186
Industrial	11,413	11,651	11,165	10,806	10,661	10,596	10,566	171,962
Tuna	13,742	13,742	13,742	13,742	13,742	13,742	13,742	211,250
Freshwater	121,448	125,031	125,819	123,426	123,238	123,223	123,221	1,908,508
Total	218,230	229,057	223,082	210,408	205,243	202,388	200,619	3,351,558
Opportunity cost (000's)								
Marine								
Canoe								
Motorized	98,140	108,026	99,372	85,623	78,972	75,185	72,840	1,454,864
Non-motorized	34,581	38,064	35,015	30,170	27,827	26,492	25,666	512,636
Semi-industrial	3,837	3,322	2,712	2,258	1,990	1,801	1,654	41,554
Industrial	18,557	18,944	18,153	17,570	17,335	17,229	17,180	279,599
Tuna	36,987	37,953	37,953	37,953	37,953	37,953	37,953	583,436
Freshwater	224,426	231,046	232,502	228,080	227,733	227,705	227,702	3,526,758
Total	416,528	437,355	425,707	401,655	391,810	386,365	382,997	6,398,846
Labor (000's)								
Marine								
Canoe								
Motorized	90,063	99,136	91,193	78,576	72,473	68,997	66,846	1,335,126
Non-motorized	34,711	38,208	35,147	30,284	27,932	26,592	25,763	514,570
Semi-industrial	5,089	4,215	3,144	2,375	1,970	1,714	1,536	48,736
Industrial	14,288	14,586	13,976	13,528	13,347	13,265	13,228	215,273
Tuna	46,490	48,422	48,422	48,422	48,422	48,422	48,422	744,372
Freshwater	205,955	212,030	213,367	209,309	208,990	208,964	208,962	3,236,499
Total	396,597	416,597	405,250	382,495	373,133	367,956	364,756	6,094,577
EBITDA (000's)								
Marine								
Canoe								
Motorized	142,818	157,205	144,610	124,603	114,924	109,413	106,001	2,117,188
Non-motorized	67,124	73,886	67,967	58,563	54,014	51,424	49,820	995,077
Semi-industrial	3,704	3,068	2,289	1,729	1,434	1,248	1,118	35,476
Industrial	17,860	18,232	17,471	16,909	16,683	16,582	16,535	269,092
Tuna	34,093	35,510	35,510	35,510	35,510	35,510	35,510	545,873
Freshwater	326,596	336,229	338,348	331,913	331,408	331,366	331,363	5,132,306
Total	592,195	624,131	606,194	569,228	553,973	545,543	540,347	9,095,010

PERFORMANCE INDICATORS (CONT.)

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Transfers (000's)								
Marine								
Canoe								
Motorized	0	0	0	0	0	0	0	0
Non-motorized	0	0	0	0	0	0	0	0
Semi-industrial	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Tuna	0	0	0	0	0	0	0	0
Freshwater	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0
Employment								
Marine								
Canoe								
Motorized	102,480	111,951	122,298	122,298	122,298	122,298	122,298	
Non-motorized	53,084	57,990	63,349	63,349	63,349	63,349	63,349	
Semi-industrial	4,560	4,282	4,021	3,776	3,546	3,330	3,127	
Industrial	1,152	1,152	1,152	1,152	1,152	1,152	1,152	
Tuna	1,029	1,029	1,029	1,029	1,029	1,029	1,029	
Freshwater	176,064	184,211	192,734	192,734	192,734	192,734	192,734	
Total	338,369	360,615	384,584	384,339	384,109	383,893	383,690	
Processors								
Production (000's mt)	544	573	556	522	508	500	495	
Revenue (000's)	2,577,261	2,704,186	2,632,485	2,489,649	2,431,254	2,399,053	2,379,199	39,625,420
Net ec. benefits (000's)	315,889	331,582	322,755	305,027	297,782	293,786	291,322	4,856,430
Depreciation (000's)	98,595	103,461	100,712	95,236	92,996	91,761	90,999	1,515,892
Capital costs (000's)	157,517	165,290	160,899	152,151	148,573	146,599	145,382	2,421,811
Opportunity cost (000's)	335,137	351,780	342,417	323,620	315,938	311,700	309,087	5,152,377
Distribution of benefits								
Labor (000's)	355,241	372,980	363,036	342,938	334,730	330,203	327,411	5,461,131
EBITDA (000's)	394,380	413,842	402,848	380,946	371,986	367,044	363,997	6,063,568
Employment	56,930	59,772	58,179	54,958	53,643	52,917	52,470	
Aquaculture								
Production (000's mt)	10	15	20	25	30	35	40	
Revenue (000's)	28,679	42,779	56,879	67,501	76,944	85,300	92,652	900,729
Net ec. benefits (000's)	9,801	14,496	19,192	22,584	25,541	28,094	30,276	301,398
Depreciation (000's)	587	879	1,172	1,464	1,756	2,049	2,341	19,781
Capital costs (000's)	509	751	994	1,236	1,478	1,721	1,963	16,742
Opportunity cost (000's)	1,191	1,782	2,374	2,881	3,358	3,809	4,234	38,632
Distribution of benefits								
Labor (000's)	1,364	2,063	2,761	3,289	3,760	4,176	4,542	43,780
EBITDA (000's)	10,214	15,095	19,977	23,640	26,896	29,775	32,309	316,030
Employment	219	331	442	527	602	669	728	
Harvesters								
Resource rent (000's)								
Marine								
Canoe								
Motorized	35,014	38,541	35,453	30,548	28,175	26,824	25,987	519,056
Non-motorized	34,910	38,426	35,348	30,457	28,091	26,744	25,910	517,514
Semi-industrial	657	311	(149)	(453)	(567)	(605)	(609)	(1,522)
Industrial	(7,841)	(8,005)	(7,670)	(7,424)	(7,325)	(7,280)	(7,260)	(118,144)
Tuna	4,001	5,096	5,096	5,096	5,096	5,096	5,096	78,332
Freshwater	80,069	82,431	82,950	81,373	81,249	81,239	81,238	1,258,250
Total	146,809	156,800	151,027	139,597	134,720	132,017	130,363	2,253,487

PERFORMANCE INDICATORS (CONT.)

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Asset Value Per Vessel								
Marine								
Canoe								
Motorized	94,316							
Non-motorized	33,115							
Semi-industrial	78,453							
Industrial	1,494,954							
Tuna	9,543,227							
Freshwater	50,725							
All Sectors								
Added Value at Wholesale Level (000's)								
Aquaculture revenue	28,679	42,779	56,879	67,501	76,944	85,300	92,652	900,729
Processor margin	1,357,414	1,424,301	1,386,516	1,311,243	1,280,464	1,263,491	1,253,026	20,870,225
Harvest value	1,444,284	1,515,989	1,475,380	1,393,849	1,360,541	1,342,173	1,330,847	22,197,013
Total	2,830,377	2,983,070	2,918,775	2,772,593	2,717,949	2,690,964	2,676,525	43,967,967
Trade								
Export volume	75,127	77,535	77,000	75,781	75,293	75,077	74,977	
Export value (000's)	161,797	168,013	167,317	164,938	163,993	163,575	163,386	
Population (000's)	22,871	25,375	28,154	31,237	34,658	38,453	42,664	
Consumption (000's kg)	856,100	933,496	1,012,184	1,092,136	1,185,433	1,288,802	1,402,975	
Import volume	409,095	456,607	546,264	652,139	753,485	859,163	972,892	
Import value (000's)	214,560	239,479	286,501	342,030	395,184	450,609	510,257	
Consumption share	47.8%	48.9%	54.0%	59.7%	63.6%	66.7%	69.3%	
Tariffs (000's)	10,728	11,974	14,325	17,102	19,759	22,530	25,513	
Fish Resource Status								
Fishing mortality ratio (F / F_{MSY})								
Small pelagic	1.70			2.09			2.09	
Medium/large pelagic	1.62			1.88			1.84	
Migratory pelagic	1.60			1.93			1.92	
Demersal	1.31			1.56			1.55	
Cephalopod	1.23			1.23			1.23	
Small tuna	0.88			0.88			0.88	
Large tuna	0.87			0.87			0.87	
Shrimp	0.64			0.64			0.64	
Freshwater	0.90			0.99			0.99	
Stock size ratio (X / X_{MSY})								
Small pelagic	0.30			0.10			0.04	
Medium/large pelagic	0.38			0.22			0.17	
Migratory pelagic	0.40			0.18			0.12	
Demersal	0.69			0.49			0.45	
Cephalopod	0.77			0.77			0.77	
Small tuna	1.12			1.12			1.12	
Large tuna	1.13			1.13			1.13	
Shrimp	1.36			1.36			1.36	
Freshwater	1.10			1.01			1.01	

PERFORMANCE INDICATORS

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Number of vessels								
Marine								
Canoe	11,213	11,213	11,213	11,213	11,213	11,213	11,213	
Motorized	6,405	6,405	6,405	6,405	6,405	6,405	6,405	
Non-motorized	4,808	4,808	4,808	4,808	4,808	4,808	4,808	
Semi-industrial	240	240	120	120	120	120	120	
Industrial	72	72	0	0	0	0	0	
Tuna	26	26	26	26	26	26	26	
Freshwater	22,008	22,008	22,008	22,008	22,008	22,008	22,008	
Total	33,559	33,559	33,367	33,367	33,367	33,367	33,367	
Landed catch (000's mt)								
Marine								
Canoe	231.9	247.4	253.6	257.5	258.7	258.9	259.0	
Motorized	160.3	170.9	175.3	178.0	178.8	178.9	179.0	
Non-motorized	71.7	76.4	78.4	79.6	79.9	80.0	80.0	
Semi-industrial	8.0	7.6	4.0	4.2	4.3	4.3	4.3	
Industrial	17.6	18.3	0.0	0.0	0.0	0.0	0.0	
Tuna	68.9	71.8	71.8	71.8	71.8	71.8	71.8	
Freshwater	319.0	320.6	320.6	320.6	320.6	320.6	320.6	
Total	645.5	665.7	650.1	654.2	655.4	655.7	655.7	
Harvest value (000's)								
Marine								
Canoe	440,241	469,508	486,202	498,626	500,829	501,345	501,386	7,502,260
Motorized	332,424	354,523	367,129	376,510	378,173	378,563	378,594	5,664,919
Non-motorized	107,817	114,985	119,073	122,116	122,656	122,782	122,792	1,837,341
Semi-industrial	17,450	16,539	8,865	9,333	9,499	9,569	9,599	174,140
Industrial	71,438	74,093	0	0	0	0	0	322,321
Tuna	154,968	161,408	161,408	161,408	161,408	161,408	161,408	2,481,239
Freshwater	760,186	764,112	771,753	779,395	779,395	779,395	779,395	11,869,726
Total	1,444,284	1,485,661	1,428,228	1,448,762	1,451,131	1,451,717	1,451,788	22,349,685
Catch (mt) per vessel								
Marine								
Canoe	20.7	22.1	22.6	23.0	23.1	23.1	23.1	
Motorized	25.0	26.7	27.4	27.8	27.9	27.9	27.9	
Non-motorized	14.9	15.9	16.3	16.5	16.6	16.6	16.6	
Semi-industrial	33.3	31.6	33.5	34.9	35.5	35.8	35.9	
Industrial	244.8	253.9	n/a	n/a	n/a	n/a	n/a	
Tuna	2,651.3	2,761.5	2,761.5	2,761.5	2,761.5	2,761.5	2,761.5	
Freshwater	14.5	14.6	14.6	14.6	14.6	14.6	14.6	
Net economic benefits (000's)								
Marine								
Canoe								
Motorized	101,498	108,246	112,095	114,959	115,467	115,586	115,596	1,729,660
Non-motorized	56,473	60,227	62,369	63,963	64,245	64,311	64,317	962,372
Semi-industrial	4,147	3,821	2,123	2,291	2,351	2,376	2,386	41,652
Industrial	6,446	6,686	0	0	0	0	0	29,086
Tuna	34,994	37,377	37,377	37,377	37,377	37,377	37,377	574,580
Freshwater	232,106	233,305	235,638	237,971	237,971	237,971	237,971	3,624,163
Total	435,666	449,662	449,602	456,561	457,411	457,622	457,647	6,961,513

PERFORMANCE INDICATORS (CONT.)

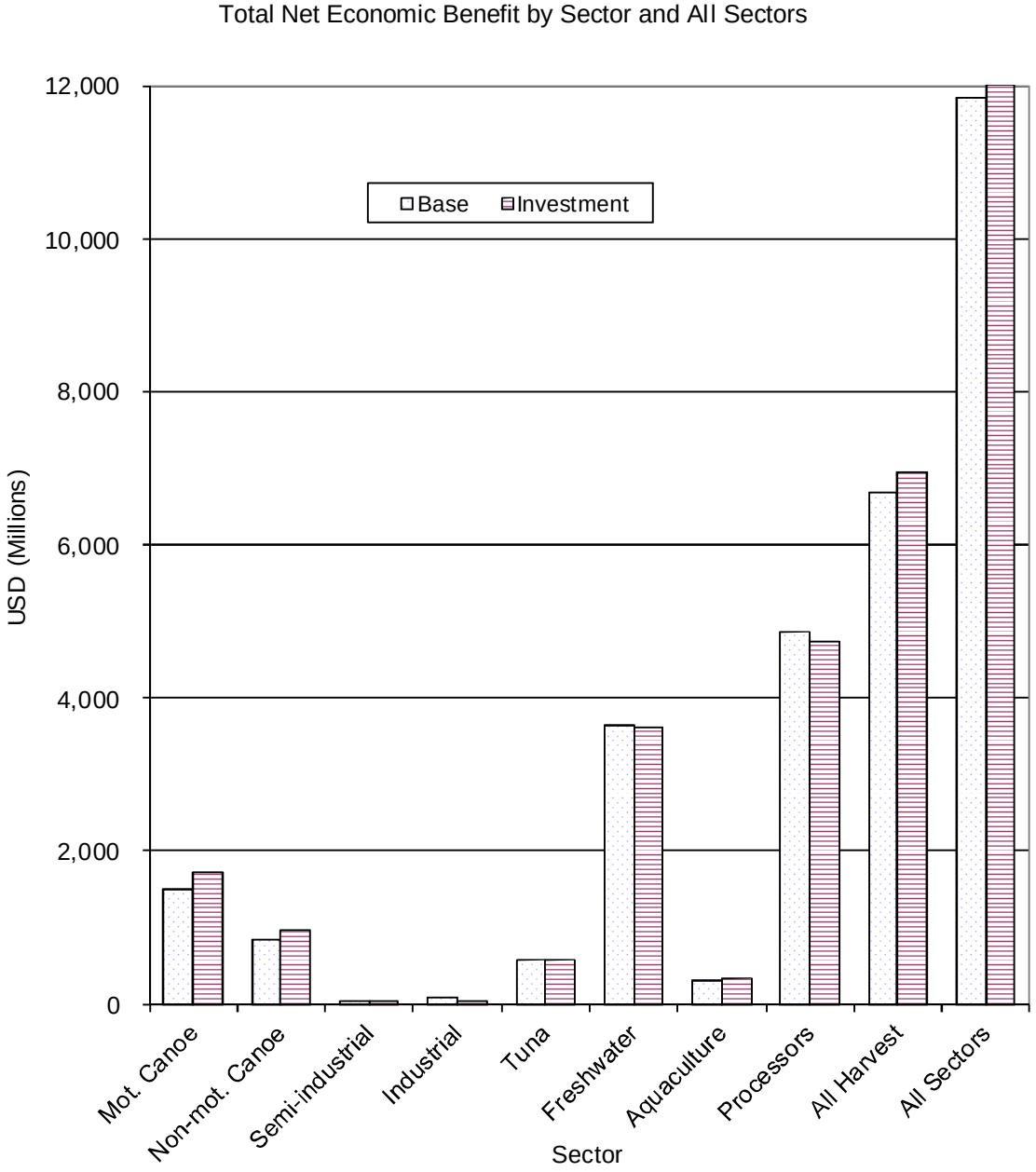
	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Depreciation (000's)								
Marine								
Canoe								
Motorized	33,242	35,452	36,713	37,651	37,817	37,856	37,859	566,492
Non-motorized	10,782	11,498	11,907	12,212	12,266	12,278	12,279	183,734
Semi-industrial	809	809	405	405	405	405	405	7,971
Industrial	7,144	7,409	0	0	0	0	0	32,232
Tuna	8,602	8,602	8,602	8,602	8,602	8,602	8,602	132,228
Freshwater	76,019	76,411	77,175	77,939	77,939	77,939	77,939	1,186,973
Total	136,597	140,182	134,802	136,808	137,029	137,080	137,084	2,109,630
Capital cost (000's)								
Marine								
Canoe								
Motorized	53,109	56,639	58,653	60,152	60,418	60,480	60,485	905,036
Non-motorized	17,225	18,370	19,023	19,509	19,596	19,616	19,617	293,536
Semi-industrial	1,293	1,293	646	646	646	646	646	12,735
Industrial	11,413	11,837	0	0	0	0	0	51,494
Tuna	13,742	13,742	13,742	13,742	13,742	13,742	13,742	211,250
Freshwater	121,448	122,076	123,296	124,517	124,517	124,517	124,517	1,896,325
Total	218,230	223,957	215,361	218,567	218,919	219,001	219,008	3,370,377
Opportunity cost (000's)								
Marine								
Canoe								
Motorized	98,140	104,664	108,386	111,155	111,646	111,761	111,771	1,672,427
Non-motorized	34,581	36,879	38,191	39,167	39,340	39,380	39,383	589,296
Semi-industrial	3,837	3,704	1,939	2,007	2,031	2,042	2,046	38,128
Industrial	18,557	19,247	0	0	0	0	0	83,726
Tuna	36,987	37,953	37,953	37,953	37,953	37,953	37,953	583,436
Freshwater	224,426	225,585	227,841	230,097	230,097	230,097	230,097	3,504,244
Total	416,528	428,033	414,310	420,380	421,068	421,234	421,251	6,471,257
Labor (000's)								
Marine								
Canoe								
Motorized	90,063	96,050	99,465	102,007	102,458	102,563	102,572	1,534,783
Non-motorized	34,711	37,019	38,335	39,314	39,488	39,529	39,532	591,520
Semi-industrial	5,089	4,823	2,585	2,722	2,770	2,791	2,799	50,785
Industrial	14,288	14,819	0	0	0	0	0	64,464
Tuna	46,490	48,422	48,422	48,422	48,422	48,422	48,422	744,372
Freshwater	205,955	207,019	209,089	211,160	211,160	211,160	211,160	3,215,838
Total	396,597	408,152	397,897	403,625	404,298	404,465	404,485	6,201,762
EBITDA (000's)								
Marine								
Canoe								
Motorized	142,818	152,312	157,728	161,759	162,473	162,641	162,654	2,433,796
Non-motorized	67,124	71,587	74,132	76,026	76,362	76,441	76,447	1,143,882
Semi-industrial	3,704	3,511	1,882	1,981	2,016	2,031	2,038	36,967
Industrial	17,860	18,523	0	0	0	0	0	80,580
Tuna	34,093	35,510	35,510	35,510	35,510	35,510	35,510	545,873
Freshwater	326,596	328,282	331,565	334,848	334,848	334,848	334,848	5,099,542
Total	592,195	609,726	600,817	610,124	611,210	611,471	611,497	9,340,640

PERFORMANCE INDICATORS (CONT.)

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Transfers (000's)								
Marine								
Canoe								
Motorized	0	0	1,836	1,883	1,891	1,893	1,893	20,508
Non-motorized	0	0	595	611	613	614	614	6,652
Semi-industrial	0	0	44	47	47	48	48	504
Industrial	0	0	0	0	0	0	0	0
Tuna	0	0	807	807	807	807	807	8,912
Freshwater	0	0	3,859	3,897	3,897	3,897	3,897	42,808
Total	0	0	7,141	7,244	7,256	7,259	7,259	79,384
Employment								
Marine								
Canoe								
Motorized	102,480	102,480	102,480	102,480	102,480	102,480	102,480	
Non-motorized	53,084	53,084	53,084	53,084	53,084	53,084	53,084	
Semi-industrial	4,560	4,560	2,280	2,280	2,280	2,280	2,280	
Industrial	1,152	1,152	0	0	0	0	0	
Tuna	1,029	1,029	1,029	1,029	1,029	1,029	1,029	
Freshwater	176,064	176,064	176,064	176,064	176,064	176,064	176,064	
Total	338,369	338,369	334,937	334,937	334,937	334,937	334,937	
Processors								
Production (000's mt)	544	561	547	550	551	551	551	
Revenue (000's)	2,577,261	2,651,691	2,488,862	2,523,876	2,527,943	2,528,953	2,529,077	39,215,328
Net ec. benefits (000's)	315,889	324,982	297,670	301,881	302,372	302,493	302,508	4,724,544
Depreciation (000's)	98,595	101,448	88,985	90,222	90,368	90,404	90,408	1,430,942
Capital costs (000's)	157,517	162,074	142,164	144,140	144,373	144,431	144,438	2,286,094
Opportunity cost (000's)	335,137	344,788	315,042	319,495	320,014	320,143	320,158	5,003,906
Distribution of benefits								
Labor (000's)	355,241	365,427	345,756	350,710	351,283	351,424	351,441	5,435,625
EBITDA (000's)	394,380	405,791	355,941	360,889	361,471	361,616	361,634	5,723,768
Employment	56,930	58,562	55,410	56,204	56,295	56,318	56,321	
Aquaculture								
Production (000's mt)	10	15	20	25	30	35	40	
Revenue (000's)	28,679	42,779	56,879	67,501	76,944	85,300	92,652	900,729
Net ec. benefits (000's)	9,801	15,266	21,282	25,717	29,874	33,764	37,399	339,913
Depreciation (000's)	587	879	1,172	1,464	1,756	2,049	2,341	19,781
Capital costs (000's)	509	751	994	1,236	1,478	1,721	1,963	16,742
Opportunity cost (000's)	1,191	1,782	2,374	2,881	3,358	3,809	4,234	38,632
Distribution of benefits								
Labor (000's)	1,364	2,063	2,761	3,289	3,760	4,176	4,542	43,780
EBITDA (000's)	10,214	15,866	22,067	26,772	31,229	35,446	39,432	354,545
Employment	219	331	442	527	602	669	728	
Harvesters								
Resource rent (000's)								
Marine								
Canoe								
Motorized	35,014	37,341	38,669	39,657	39,832	39,873	39,877	596,676
Non-motorized	34,910	37,230	38,554	39,539	39,714	39,755	39,758	594,904
Semi-industrial	657	513	350	425	451	462	467	6,825
Industrial	(7,841)	(8,133)	0	0	0	0	0	(35,378)
Tuna	4,001	5,096	5,096	5,096	5,096	5,096	5,096	78,332
Freshwater	80,069	80,483	81,287	82,092	82,092	82,092	82,092	1,250,218
Total	146,809	152,530	163,957	166,809	167,185	167,278	167,289	2,491,576

PERFORMANCE INDICATORS (CONT.)

	Years Projected From Initial Conditions							
	0	5	10	15	20	25	30	NPV
Asset Value Per Vessel								
Marine								
Canoe								
Motorized	122,853							
Non-motorized	43,134							
Semi-industrial	114,570							
Industrial	447,667							
Tuna	9,543,227							
Freshwater	53,934							
All Sectors								
Added Value at Wholesale Level (000's)								
Aquaculture revenue	28,679	42,779	56,879	67,501	76,944	85,300	92,652	900,729
Processor margin	1,357,414	1,396,636	1,287,129	1,305,180	1,307,284	1,307,807	1,307,871	20,390,380
Harvest value	1,444,284	1,485,661	1,428,228	1,448,762	1,451,131	1,451,717	1,451,788	22,349,685
Total	2,830,377	2,925,076	2,772,237	2,821,443	2,835,359	2,844,824	2,852,311	43,640,794
Trade								
Export volume	75,127	77,064	75,610	76,371	76,560	76,602	76,612	
Export value (000's)	161,797	166,776	161,369	162,891	163,267	163,352	163,371	
Population (000's)	22,871	25,375	28,154	31,237	34,658	38,453	42,664	
Consumption (000's kg)	856,100	927,342	1,004,388	1,089,324	1,183,013	1,286,414	1,400,589	
Import volume	409,095	461,451	544,391	621,835	709,752	807,958	917,116	
Import value (000's)	214,560	242,019	285,519	326,137	372,246	423,753	481,004	
Consumption share	47.8%	49.8%	54.2%	57.1%	60.0%	62.8%	65.5%	
Tariffs (000's)	10,728	12,101	14,276	16,307	18,612	21,188	24,050	
Fish Resource Status								
Fishing mortality ratio (F / F_{MSY})								
Small pelagic	1.70			1.75			1.75	
Medium/large pelagic	1.62			1.52			1.52	
Migratory pelagic	1.60			1.59			1.59	
Demersal	1.31			1.13			1.13	
Cephalopod	1.23			0.00			0.00	
Small tuna	0.88			0.88			0.88	
Large tuna	0.87			0.87			0.87	
Shrimp	0.64			0.00			0.00	
Freshwater	0.90			0.90			0.90	
Stock size ratio (X / X_{MSY})								
Small pelagic	0.30			0.26			0.25	
Medium/large pelagic	0.38			0.45			0.48	
Migratory pelagic	0.40			0.40			0.41	
Demersal	0.69			0.85			0.87	
Cephalopod	0.77			1.90			2.00	
Small tuna	1.12			1.12			1.12	
Large tuna	1.13			1.13			1.13	
Shrimp	1.36			1.92			2.00	
Freshwater	1.10			1.10			1.10	



Notes: 1. The measure is NPV of net economic benefit that includes depreciation cost, capital cost, and opportunity cost of labor. This measure treats labor as a cost based on alternative livelihood choice for skipper/crew members.

Ghana Total Net Economic Benefit for the Base, Investment, and Case Difference by Sector

Measure	Artisanal by Power Source Category			Semi-industrial	Industrial	Tuna	Freshwater	Aquaculture	Processors	All Harvest	All Sectors
	Motorized	Non-Motorized	Total								
NPV Investment Case											
Net economic benefits ($000 2009 USD)	1,729,660	962,372	2,692,032	41,652	29,086	574,580	3,624,163	339,913	4,724,544	6,961,513	12,025,970
Resource rent ($000 2009 USD)	596,676	594,904	1,191,580	6,825	(35,378)	78,332	1,250,218			2,491,576	2,491,576
Distribution of benefits ($000 2009 USD)											
Returns to labor	1,534,783	591,520	2,126,303	50,785	64,464	744,372	3,215,838	43,780	5,435,625	6,201,762	11,681,167
Returns to owners	2,433,796	1,143,882	3,577,678	36,967	80,580	545,873	5,099,542	354,545	5,723,768	9,340,640	15,418,952
Transfers to government (license fees)	20,508	6,652	27,160	504	0	8,912	42,808	0	0	79,384	79,384
NPV Base Case											
Net economic benefits ($000 2009 USD)	1,504,652	837,179	2,341,831	31,901	97,130	574,580	3,647,448	301,398	4,856,430	6,692,889	11,850,717
Resource rent ($000 2009 USD)	519,056	517,514	1,036,570	(1,522)	(118,144)	78,332	1,258,250			2,253,487	2,253,487
Distribution of benefits ($000 2009 USD)											
Returns to labor	1,335,126	514,570	1,849,697	48,736	215,273	744,372	3,236,499	43,780	5,461,131	6,094,577	11,599,488
Returns to owners	2,117,188	995,077	3,112,265	35,476	269,092	545,873	5,132,306	316,030	6,063,568	9,095,010	15,474,608
Transfers to government (license fees)	0	0	0	0	0	0	0	0	0	0	0
Net Benefit (Investment Minus Base Case)											
Net economic benefits ($000 2009 USD)	225,008	125,193	350,201	9,751	(68,044)	0	(23,285)	38,515	(131,885)	268,624	175,253
Resource rent ($000 2009 USD)	77,620	77,390	155,010	8,346	82,765	0	(8,032)			238,090	238,090
Distribution of benefits ($000 2009 USD)											
Returns to labor	199,657	76,950	276,607	2,049	(150,809)	0	(20,661)	0	(25,506)	107,185	81,679
Returns to owners	316,608	148,806	465,414	1,491	(188,512)	0	(32,764)	38,515	(339,800)	245,629	(55,656)
Transfers to government (license fees)	20,508	6,652	27,160	504	0	8,912	42,808	0	0	79,384	79,384

Notes: 1. The table measure is NPV of net economic benefits which is sometimes called economic rent. Net economic benefits includes depreciation cost, and opportunity cost of labor and capital. The opportunity cost of labor is based on alternative livelihood choice for skipper/crew members.

2. The distribution of harvest net economic benefits is among three groups: incomes to skipper/crew; net income to hull, motor, gear and other owners; and, net transfers to government. Taxes on sector profits are not included.

Source: Study.