FISH-BE MODEL

Fisheries Information for Sustainable Harvests Bio-Economic Model

USER'S GUIDE

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The Philippine Environmental Governance Project

FISH-BE 1 Model User's Guide

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Authors: Wilfredo Y. Licuanan and Gem B. Castillo.
Editing, design supervision, and print production: Elaine Martinez-Umali.
Book design and illustrations: Randolf Gustaf P. Luna.

EcoGov2 is a collaborative effort resulting from the bilateral agreement between the United States government through USAID and the government of the Philippines through the Department of Environment and Natural Resources and the Department of the Interior and Local Government. EcoGov2 focuses on strengthening local government units or LGUs so that they can carry out localized but strategic actions that aim to

- Reduce overfishing and the use of destructive fishing practices;
- Reduce illegal logging and promote the conversion of natural forests; and
- Improve the management of solid wastes and wastewater.

EcoGov 2 provides technical assistance to some 130 strategically located LGUs to enable them to plan and implement locally financed environmental programs, while observing the principles of transparency, accountability and people's participation in all their decisions, transactions and actions.

The EcoGov2 project is managed by Development Alternatives, Inc., and its subcontractors:

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Introduction

Fisheries Information for Sustaining Harvests Bio-Economic (FISH-BE) is a communications tool and decision-support program. It is designed to facilitate interactive examination of major decision options for coastal managers, especially those concerning municipal and commercial fishing effort and fish sanctuaries. With FISH-BE, managers can estimate the minimum size of the marine protected area (MPA) needed to support municipal fisheries with or without commercial fishers in a town's coastal waters (i.e., within a user definable distance of 10.1 to 15 km from shore where such may be allowed). Managers can also determine the effects of the number of fishers, catch per fisher, and number of fishing days on the total catch. FISH-BE also provides estimates on costs and returns of management, both to fishers and to the local government.

The FISH-BE Model 1 is implemented using a modeling program called Stella®. FISH-BE is graphical, easy to use, and only requires data that are readily available. It also allows users to gain important insights on the ecology and economics of fisheries in the Philippines and determine how these may be managed in a sustainable manner. As a communications tool, FISH-BE can be a useful basis for providing various stakeholders a perspective on the intricacies of coastal resource management. As a decision support tool, it provides the technical foundation for adaptive management by facilitating transparent and accountable environmental governance with participatory decision making.

FISH-BE was built on a core model originally developed by Wilfredo Licuanan. FISH-BE was later expanded by a team led by him and Gem Castillo for the Philippine Environmental Governance 2 (EcoGov2) Project, a United States Agency for International Development (USAID) funded project.

Who can we contact to get a copy of FISH-BE and how can we learn how to use it?

FISH-BE was developed for local government units (LGU) to help them effectively manage municipal waters. Oftentimes, resource managers of LGUs have limited data and access to expertise to make sound management decisions. With FISH-BE, LGUs can maximize the use of available data and expertise, and set the foundation for more improved management of coastal resources.

The EcoGov2 Project continues to support the development of FISH-BE and offers training and support to its application, often in collaboration with local governments with adjoining waters. You may contact Porfirio Aliño, Ph.D., the Coastal Resource Management (CRM) sector leader of EcoGov2 at pmalino@upmsi.ph; fax: (632)-924-7678 for further details.

In what context is FISH-BE applicable?

FISH-BE was developed for local governments to manage their own coastal and marine resources (Fisheries Code, or Republic Act 8550). The parameters whose effects can be examined in FISH-BE scenarios are those applicable to towns such as the number of municipal fishers; area of coastal waters within 15 km of shore; minimum distance from shore commercial fishers are allowed to operate among others.

FISH-BE models have also been developed for embayments made up of several municipalities. FISH-BE II, a version designed for the management of networks of marine protected areas of several towns, is also currently being tested. The EcoGov Project continues to provide collective experiences of several FISH-BE models and modelers in their trainings and project sites.

What is Stella?

Stella® is a modeling program designed to make modeling faster and less tedious. Stella does this by letting modelers draw diagrams instead of typing equations (although these are still necessary). Thus, Stella lets the modeler focus more on the logic of the model rather than on the writing of the computer code itself.

Every Stella model has three "views," or levels, much like the layers of an onion. Most users are only familiar with the outer **interface level**, such as the FISH-BE interface shown in figure 1 (N.B.: Most people will be given FISH-BE versions wherein only this level is accessible). At this interface level, users can see and manipulate the inputs and observe the outputs. There are three kinds of user input devices in the interface level: **knobs, sliders,** and **list input devices** to run FISH-BE.

Knobs and sliders work the same way as those found on radio or sound system (see figure 2). Using the mouse, turn a knob clockwise (or a slider to the right) to increase a variable or parameter (e.g., volume) and counterclockwise (or a slider to the left) to decrease it.

Exact numbers may also be set by clicking on the boxed value and typing a number within the range indicated. To see which part of the model the particular knob or slider is controlling, click the small downward pointing triangle which leads to the model construction level (the middle level in Stella described on the next page).

Clicking on the small button with a "U" resets the parameter controlled to the default value (i.e., the numbers provided by the FISH-BE developers). The main difference between knobs and sliders is that sliders can be adjusted "on the fly," or while the model is running, while knobs can only be adjusted before a run.

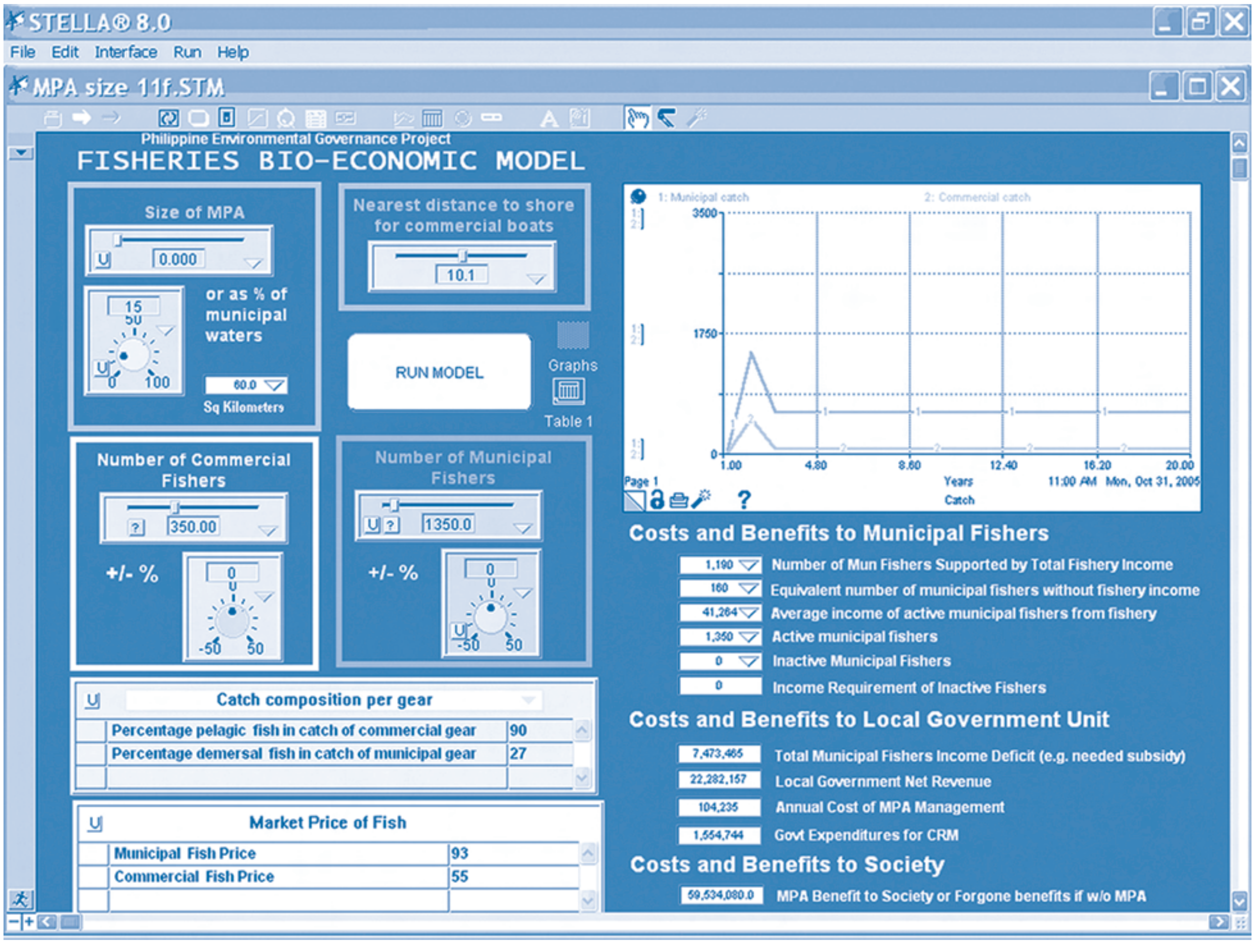


Figure 1. FISH-BE screen display

*The users of FISH-BE typically work with a screen display like this. The knobs, sliders and tables show the values the user can input and readily change for each run.

The third kind of Stella user input device, available at the interface level, is the list input device (see figures 3 and 4). These devices are often called drop-down tables in other software because clicking on the table name (with a downward pointing triangle) causes a list of tables to drop down and display.

The user may just select the appropriate table with a mouse click and add data in the appropriate rows of the numeric (second) column where the inputs are needed. Just like in knobs and sliders, data may be controlled by the programmer to fall within a certain range of numeric values.

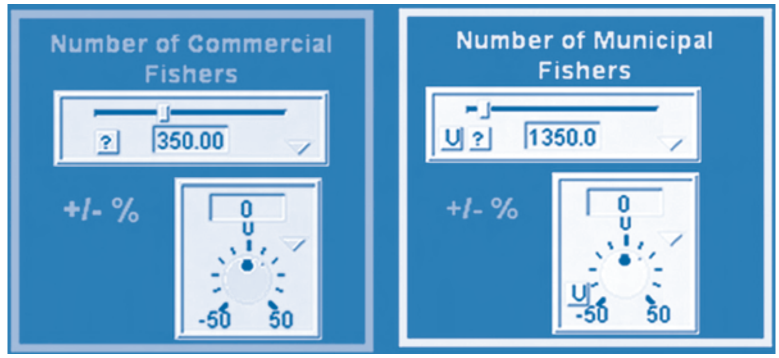


Figure 2. FISH-BE numeric boxes

*The number of fishers (commercial on the left, municipal on the right) may be input into the numeric box of the sliders and changed. These can also be adjusted using the knobs which increase or decrease the number of fishers + or - 50%.

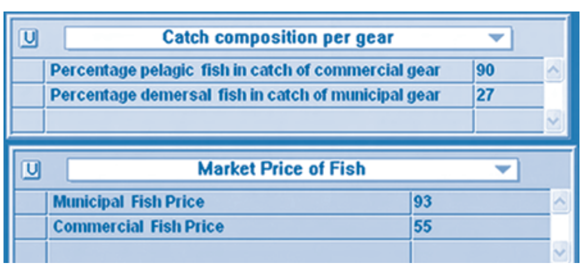


Figure 3. List input devices or drop-down tables for encoding other values such as catch composition (upper table) or price of fishes (lower table)

*Clicking on the "U" button (upper left of each table) resets all inputs for each table to the default values.

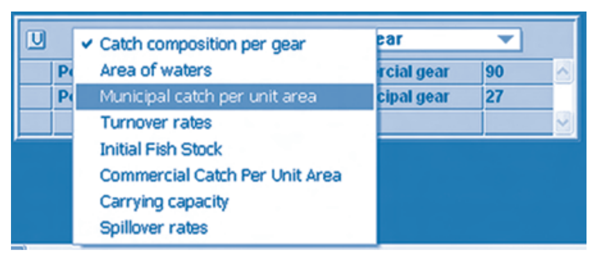


Figure 4. Other drop-down tables

*Clicking on the table title (white bar on top) drops down a list of other table titles which may be selected for adding other data to FISH-BE. Default values for turnover rates, carrying capacity, and spillover rates are already included in the model.

As mentioned earlier, clicking on the downward pointing triangle on the upper left-hand corner of the Stella model interface layer will take you to the *model construction layer* (figure 5; note that this is not accessible in some newer versions of FISH-BE; if this is the case, skip to **Preparing a site model with FISH-BE**). Here, you will see the four basic components of a Stella model diagram: the stock, flow, connector, and converters.

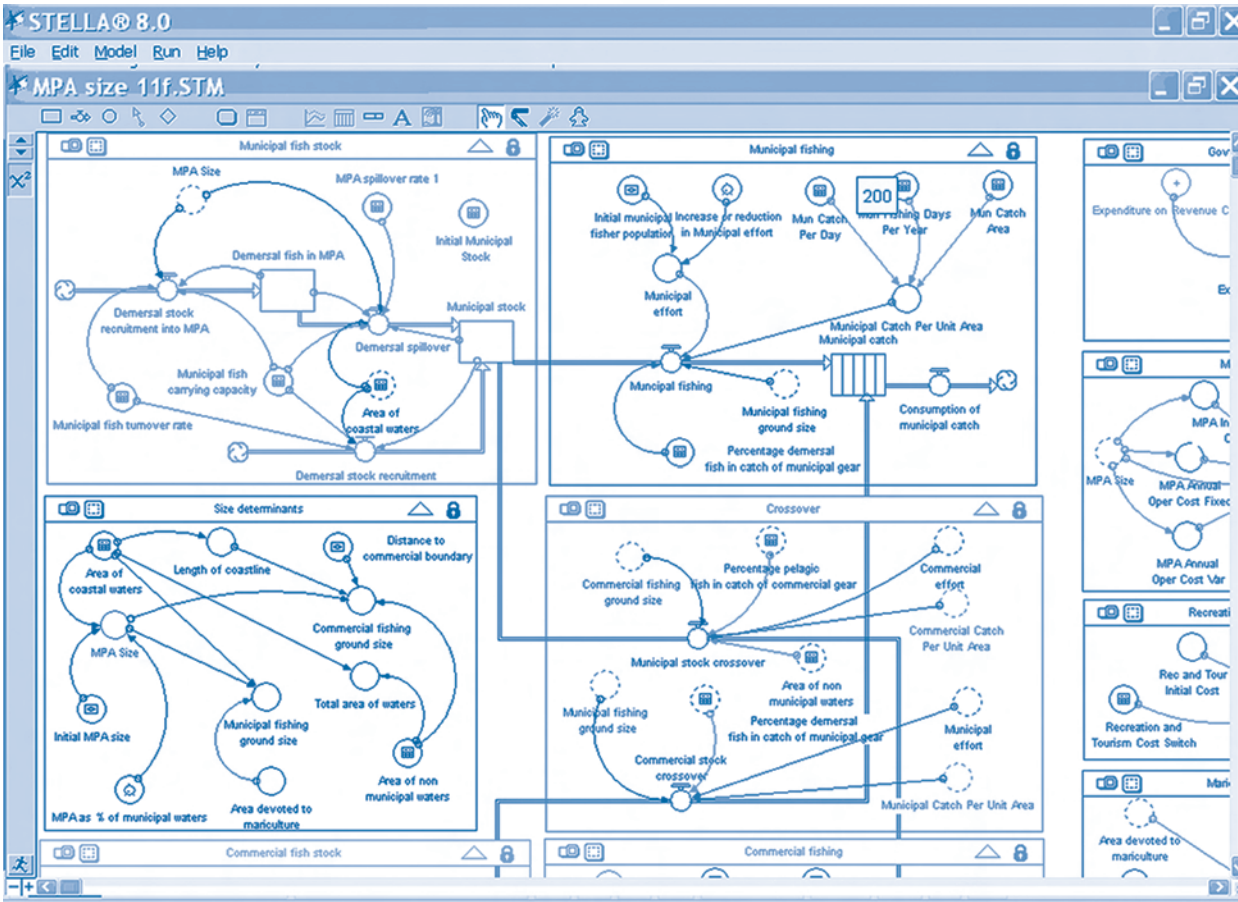


Figure 5. A section of the model construction layer of Stella, showing some of the diagrams that make up the FISH-BE model

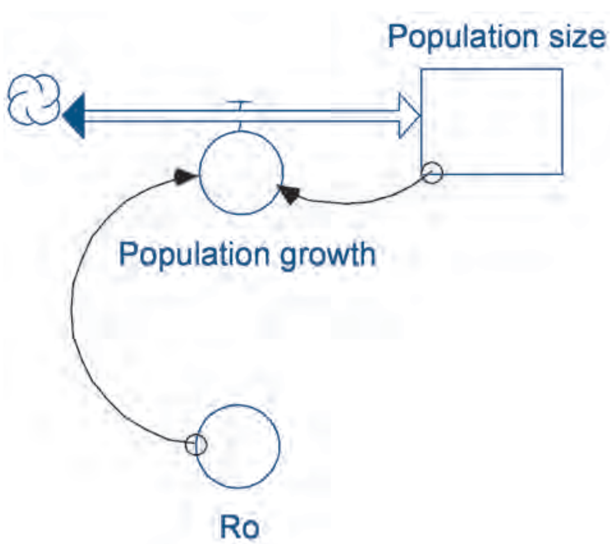


Figure 6. A typical diagrammatic Stella model showing the four basic components

The first and the basic building block of the Stella model is the stock, drawn as a rectangle (population size in figure 6). The stock represents anything that accumulates, such as number of fish in a population, liters of water in a pond, or a pollutant in a lake. The only requirement is that the accumulation should be quantifiable.

The second building block is the flow (e.g., population growth in figure 6), which represents activities or processes. It is represented as a pipe (with an arrow to indicate direction of the flow) and a circular regulator or valve to manage (using an equation or graph) the flow. Flows typically used in models are births, deaths, migrations, and flows of substances. They modify the amount or magnitude of stocks and thus flows begin and end with stocks. This does always have to be the case though. For example, entities coming out of the births flow may come out of nowhere (i.e., unlimited; depicted as a cloud) or entities coming into a deaths process will disappear (into a cloud).

The connector (the black lines in figure 6) is the third building block. It is used to convey or transfer information and inputs, usually from a stock or a converter (explained below), into a regulator of a flow or a converter. For example, if a stock represents a reservoir of water and flow, this stock represents a stream draining this reservoir. A connector connecting the stock to the flow could convey information about the amount of water in the stock, thereby determining the rate of discharge. Obviously discharge flow cannot continue if the reservoir (stock) is empty.

Converters, on the other hand (Ro in Figure 6), typically contain equations that "convert" an input into an output. Converters are also used to hold constants and other fixed inputs. For example, in the above model, the converter called Ro is used to represent the constant for rate of growth of the population. A connector from this converter conveys this information into the population growth flow where birth and death rates are determined. Converters are not as intuitive as the other building blocks but will become more "natural" with time and practice.

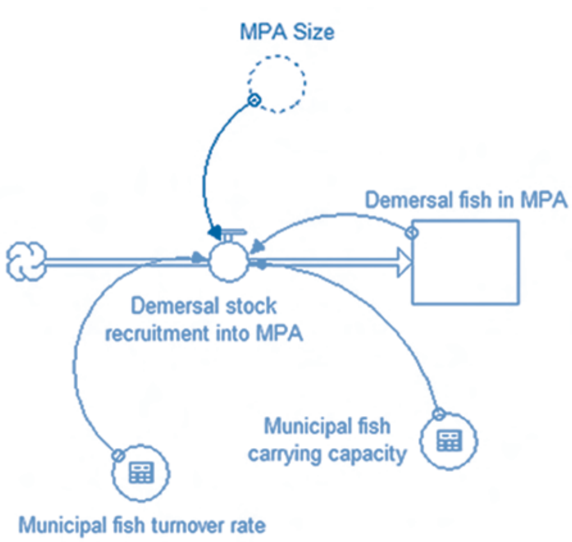


Figure 7. Part of the model construction layer of FISH-BE I showing how the stock inside the MPA grows

Figure 7 shows how the different model building blocks described above are put together in FISH-BE to model the growth of the fish stock inside the MPA. The stock grows as determined by the municipal fish turnover rate (essentially, the number of times in a year the fish stock replaces itself) multiplied by the size of the stock inside the MPA (Demersal fish in MPA). The latter, in turn, is determined by an initial demersal fish stock size (Initial municipal stock) which is in metric tons per square kilometer, multiplied by the MPA size also in square kilometers. The rate of the fish stock inside the MPA grows slowly as it approaches the municipal fish carrying capacity which sets the limit on how much fish waters of a given area can hold.

In the FISH-BE code, the terms "municipal fish" and "demersal fish" refer to the same fish stock. This is simplified to just "demersal fish" in the Philippine agricultural scientist paper. Users interested in the computational details of the municipal FISH-BE Model (termed Model 1) are referred to this paper.

The basic components described above are used, along with some equations, to define models. When the modeler draws a diagram using the above components, Stella starts putting together equations, the heart of the model. You can see the equation level (see figure 8) by clicking on the downward pointing triangle in the upper left corner of the model construction layer.

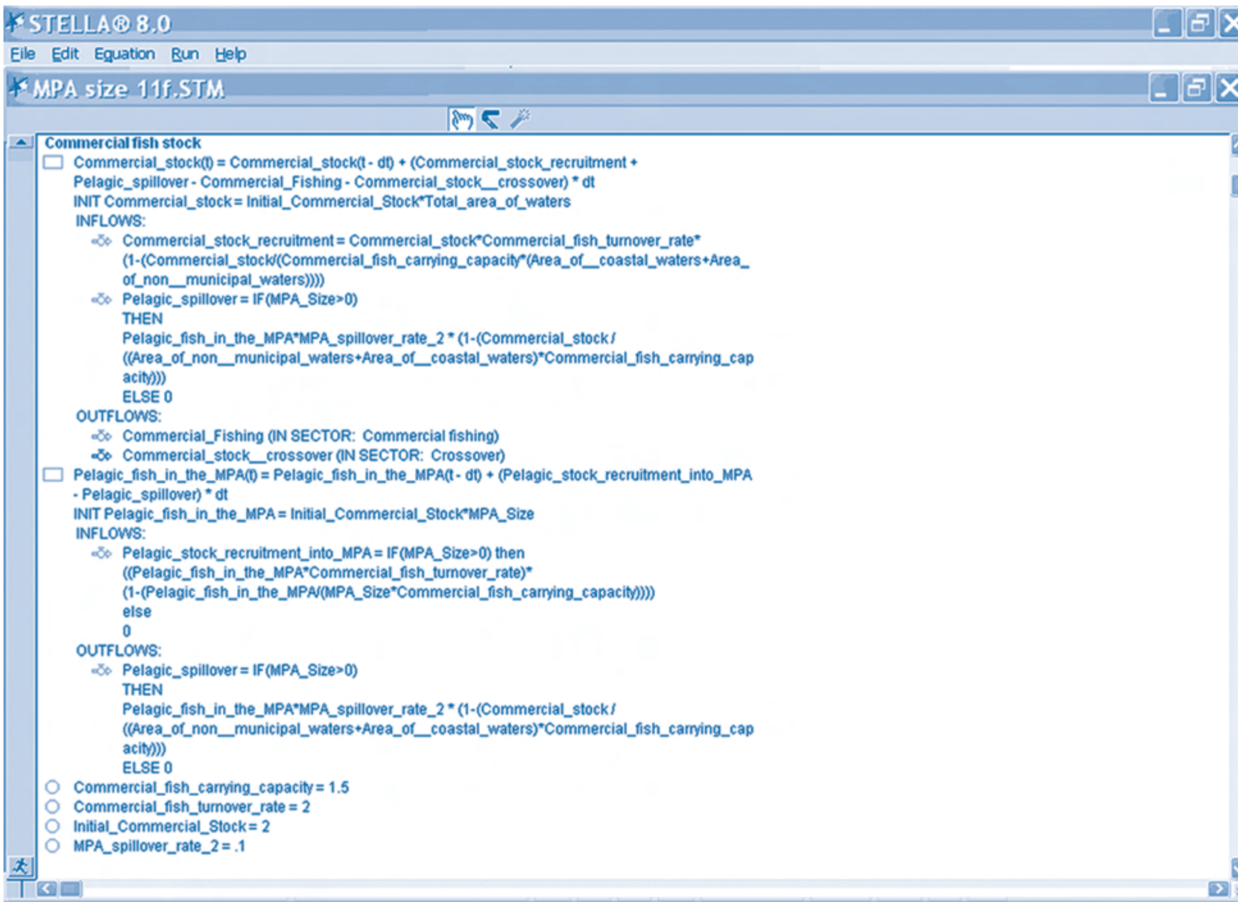


Figure 8. Part of the equation level of FISH-BE

*This is the innermost of three levels in Stella. To move to the model construction layer, click on the triangle on the upper left of the equation level. The computational details of how pelagic fish stocks grow inside the MPA can be seen here. The Pelagic fish in the MPA is the pelagic fish equivalent of the diagram shown in figure 7.

Preparing a Site Model with FISH-BE

What are the minimum inputs in order to have a FISH-BE simulation?

FISH-BE was originally designed to work at the level of an individual town to describe its fisheries in terms of the size of the municipal waters, the number of fishers (both municipal and commercial. These are distinguished by law on the basis of whether they use vessels smaller than or bigger than 3 gross tons), their catch over a given area and number of fishing days, the composition of their catch in terms of demersal (soft and hard bottom-living) fishes and pelagic (widely roaming fish) fishes, and estimates of the amount of these fishing found in the municipal waters. Simple economic analyses are also made possible if average prices of demersal and pelagic fishes are factored in along with fishery-related fees imposed by the municipality (where applicable).

Table 1. The minimum data inputs to run the FISH-BE model

Data required and typical sources	Units
Number of municipal fishers—Typically derived from data of the municipal agriculture/fishery office	• Fishers
Number of commercial fishers—Typically derived from data of the municipal agriculture/fishery office	• Fishers
Area of municipal waters (i.e., 15 km from shore). However, simulations will be more precise if area is input in 1 km intervals (i.e., 15, 14, 13, 12, 11, 10.1 km from shore)	• Km^2
Initial biomass: demersal fish—Derived usually from experimental fishing and visual censuses. Examples of demersal fish are leiognathids, sapsap (soft bottom) and various reef fishes such as serranids groupers lapu-lapu	• Metric tons per km^2
Initial biomass: pelagic fish—Derived usually from experimental fishing (fishery independent designed sampling) and visual censuses. Examples of pelagic fish are jacks, scombrids, and various tunas. If this is not available, a default value of 1.0 is suggested.	• Metric tons per km^2

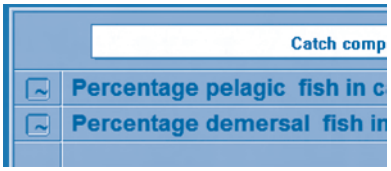
Data required and typical sources	Units
Catch per unit area: per municipal fisher—Catch is input by dividing total production of municipal fishers by the number of municipal fishers. The median number of fishing days per year, and the area over which the municipal gears are typically used in a year are also needed. Data is typically derived from the municipal agriculture/fishery office, focus group discussions, and interviews with fishers.	• Catch (in kg) per fisher per day • Median number of fishing days per year • Mean area fished in km^2 per year
Catch per unit area: per commercial fisher—Catch is input by dividing total production of commercial fishers by the number of commercial fishers. The median number of fishing days per year, and the area over which the commercial gears are typically used in a year are also needed. Data is typically derived from the municipal agriculture/fishery office, focus group discussions, and interviews with fishers.	• Catch in kg per fisher per day • Median number of fishing days per year • Mean area fished in km^2 per year
% demersal fish in municipal catch	• Percent
% pelagic fish in commercial catch	• Percent

These inputs are adjusted in the model mostly in the controls shown in figure 9. The number of fishers is adjusted using the appropriate sliders. Other biophysical inputs are encoded in the upper list input device (the magenta one; referred to here as the **biophysical list input device**) while the economic inputs are encoded in the lower list (the blue one or the **socioeconomic list input device**). The number of municipal and commercial fishers can be entered directly on the sliders.

The area of coastal waters is encoded in the biophysical list input device. The same table contains an option to enter the area of nonmunicipal waters (which is not used in the present version of the model) for simulations where fishers fish far beyond the municipal waters or in waters of adjacent towns.

In the generalized municipal scale version of FISH-BE that is being distributed, the area for municipal waters is computed by keying in the coastline length in km multiplied by 15 km [Licuanan et al. 2006]. The area exclusive to municipal fishers is computed based on whatever distance between 10.1 km to 15 km that the user decides to simulate.

The catch per unit area for municipal and commercial fishers have their own tables in the biophysical list input device. These parameters are entered as three different numbers as described in table 1: catch (in kg) per fisher per day, median number of fishing days per year, and mean area fished in km^2 per year. The latter is not typically collected in fishery monitoring studies but can be computed from gear maps. Although this estimate can also be generated from discussions and interviews with fishers, it (and even gear maps to a lesser degree) is not intuitive to many fishers and thus it is either overestimated (which leads to underestimation of fishing effort) or underestimated (which leads to overestimation of fishing effort). It may be better to use knowledge of the bathymetry of the area, coupled with understanding of the capabilities of the fishing gears used in a given community. Readers are referred to Campos's companion manual on fisheries data collection.



The catch composition (percentage of demersal fish in municipal catch and percentage of pelagic fish in commercial catch) are needed only if short-term (5-10 year) simulations are planned. Otherwise, the model allows this to vary with the availability of the demersal and pelagic fishes that is the fishers target more of the fishes that are abundant. The variable catch composition simulations are activated by clicking the ~ (in the left hand column) in the appropriate table in the biophysical list input device. Like in other fishery parameters, the user is referred to Campos's manual on fisheries data collection.

The minimum socioeconomic data inputs to the model are the price of fish, estimates of average total expenditure of each municipal and commercial fishers, government fees and charges from fishery, expenditures on coastal resources management, costs and revenues from establishing an MPA.

Costs and benefits to society are supplemental data used to evaluate total economic value of any fishery decisions. These data are input to the second lid input device (LID) in the main interface.

The price of fish is important for the welfare of fishers. Fishing to meets the fishers' daily expenditure requirements—assuming that a very significant part is dependent on fishing. In which case, both the price of fish and total fish catch (translates into income from fishery) determine how much expenditure requirement can be met by fishing activities.

These two data give the total income from fishery, and how much of the total fishers' expenditure requirements can be met. Thus, fishers' daily expenditure requirement is an important data in evaluating the socioeconomic impacts of fishery management decisions. For instance, the size of an MPA reduces the area for fishing and ultimately, fish catch. This data is usually obtained through surveys or focus group discussion, a standard procedure in participatory coastal resource assessment (PCRA).

Government investment, expenditures, and decisions on the use of revenue from coastal resources or fishery management affect fishery productivity and the welfare of fishers. For instance, the productivity of the MPA is partly determined by government investment for its protection and maintenance. Likewise, the use of government revenue for fishers' subsidy will improve the fishers' welfare. Thus, the net revenue from coastal resources or fishery management (total revenue less total expenditures) translates into funds for subsidies to fishers negatively affected by fishery regulations.

Table 2 summarizes data requirements to evaluate the socioeconomic impact of fishery decisions and actions.

Table 2. The minimum socioeconomic data inputs to run the FISH-BE model

Data required and typical sources	Units
Average price of demersal fish	P/kg
Average price of pelagic fish	P/kg
Estimates of average daily and/or monthly total expenditures of municipal and commercial fishers. Data is obtained from surveys or focus group discussions or applying results of analysis from fishery economics studies for the site under evaluation	P/day
Government Costs and Revenues	
• Fees collected by the government related to fishing (e.g., licensing, marketing, transport, entrance fees, other fixed fees). Data is obtained from interviews with municipal officers concerned.	P/month P/year
• Expenditures on coastal resources management. Data are derived from cost estimates of activities to implement coastal resources management. The list input device includes several coastal zones. Costs of zones that do not apply are converted to 0, otherwise the value 1 is retained.	P/year
• Cost and revenues in establishing a marine sanctuary. Data may be obtained from actual costs of establishment or derived from various estimates of different management regime. Data maybe disaggregated by type of fees and charges received from operating the MPA.	P invested P/Year
• Average values of fines and penalties collected from fishery. Data may be obtained from municipal officials or through estimates of other studies of similar conditions.	P/unit

Most data inputs can be taken from the socioeconomic component of the PCRA. The data come from the municipal profile, fisheries and socioeconomic assessment, and workshops conducted with selected fishers and technical working group of the municipality. In the present model, the investment and operating expenses for MPA were derived from costs and expenditure values of some MPAs established in various places in the Philippines. The cost estimates of various management zones were based on the workshop on coastal zoning as part of the development of the CRM Plan. Site specific investments and operating expenses for MPAs may substitute these values.

The costs and benefits to society for the establishment of MPAs are supplemental information. The existing data on Benefits and Cost Variable may be retained since it is assumed to approximate most of the sites in the country. The existing data are actually ranges of values which are indeterminate.

Data inputs are derived from estimates of economic studies on valuation of MPAs from sites with similar conditions. These values may be replaced in the second LID if estimates are available for the site under evaluation. Table 3 summarizes this supplemental data.

Table 3. Supplemental information to determine total economic value of MPA establishment

Society Costs and Benefits of MPA	
• Net benefits of aesthetic and biodiversity conservation	P/Year
• Net benefits of live fish export	P/Year
• Net benefits of tourism and recreation	P/Year
• Net loss due to coastal protection w/o MPA	P/Year
• Net loss to fishery w/o MPA	P/Year
• Net loss or benefit to individual fishers w/o MPA	P/Year

The critical values to be reviewed or changed are the prices, costs, total expenditures, and revenues. Table 1b gives a summary of this data input requirements.

It is highly recommended that initial results from FISH-BE simulations be considered tentative or preliminary. It is also recommended that a more focused fishery-monitoring program be implemented and that data specific for FISH-BE analyses are collected during the monitoring.

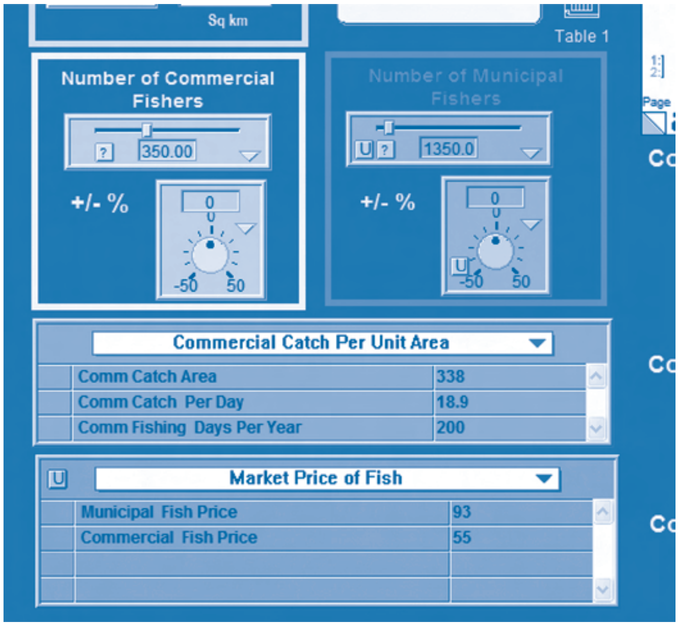


Figure 9a and b. FISH-BE input tables

*Most inputs needed to run FISH-BE can be encoded in this part of the model interface, especially the biophysical (upper or magenta) list input device. The input table for municipal fishers is shown in 9a (the upper panel), and the input table for commercial fishers is shown in 9b (the lower panel).

Running Your FISH-BE Models

Once all the numbers outlined in table 1 are entered, one is ready to run FISH-BE simulations for your area of interest. You can estimate the minimum MPA size needed, or the levels of fishing effort that the area can support. Before doing so, it should be kept in mind that there is no perfect model or simulation. Models are simplified abstractions of reality, and therefore cannot accurately capture the behavior of the system of interest while being able to remain generalized over a wide variety of situations.

Models are always compromises of data quality, knowledge about the system modeled, and uncertainty about future conditions. It is thus prudent to expect that several, slightly different simulations with adjusted inputs and constraints will have to be made for the system one is studying. In fact, one will find (if not noticed already) that one will learn more about the system of interest (even if it is just what one doesn't know about) as one interacts with the model and examine various scenarios. The lessons learned lie in the journey, not the destination.

Also, keep in mind that one has to **systematically** vary the inputs **one at a time** to better understand the system one is modeling. Remember though that just because one can adjust a number of things in the model means that one should. This will be discussed in detail in the **Refining your FISH-BE models** section.

Estimating the Minimum MPA Size

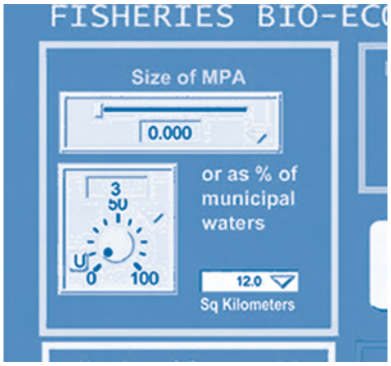


Figure 10. Controls for setting MPA size either in square kilometers (using the slider), or in percentage of the municipal waters (using the knob)

The equivalent of the latter in square kilometers is computed during a run and shown in the box on the lower right.

Estimating the minimum MPA size needed for the area of interest is simple. Type a number in the % MPA size knob (where "3" is shown in Figure 10), then click the "RUN MODEL" button, and see whether the municipal catch plotted on the line graph (figure 11) remains the same, non-zero level by the end of the 20-year simulation. Try a series of numbers, increasing the numbers (i.e., larger sizes) until the catch stabilizes as in figure 11. The smallest MPA that can produce a similar result is the minimum MPA size for the ecosystem modeled.

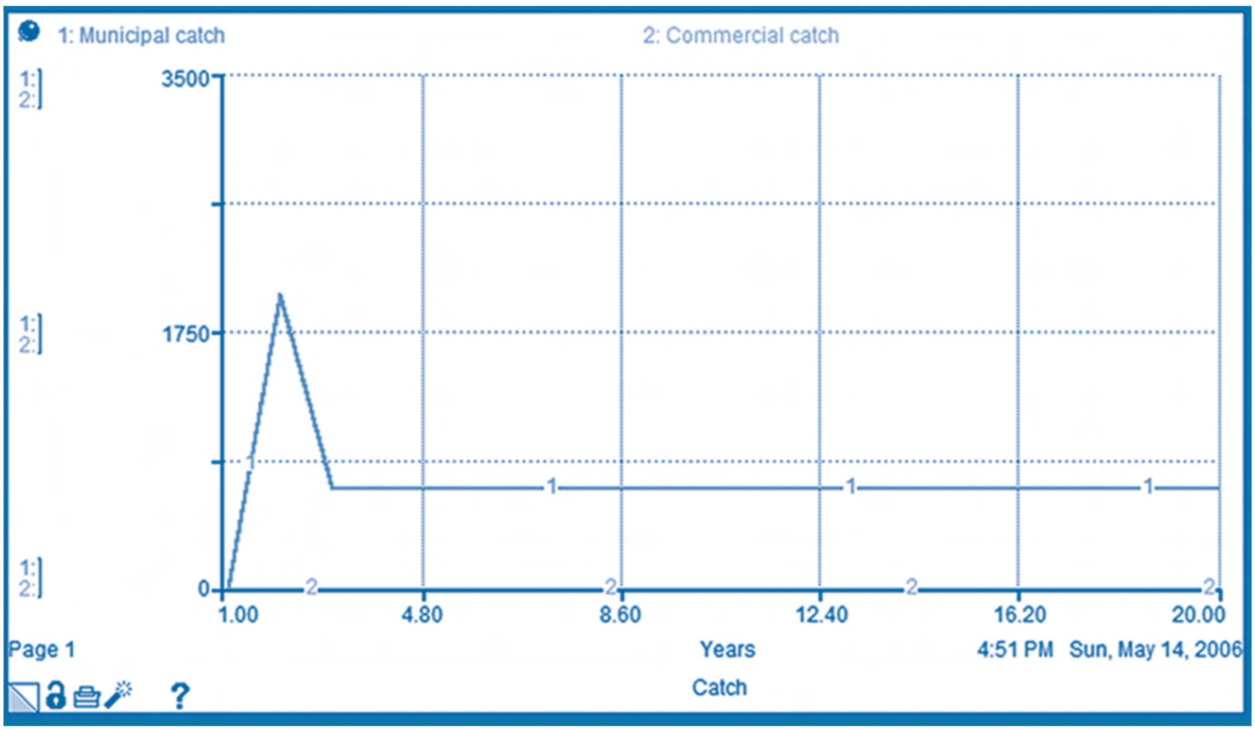


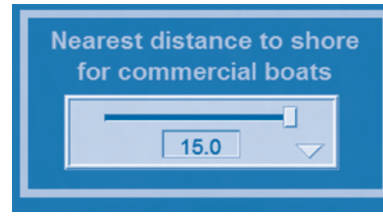
Figure 11. A sample graph from the FISH-BE interface showing the results of a simulation wherein MPA size was sufficient to maintain municipal catch at a sustainable level

Estimating Fishery Capacity

FISH-BE can also compute the number of municipal and commercial fishers that the municipal waters can support at input catch and effort levels. This is done by setting % MPA size to zero, and trying various numbers of municipal or commercial fishers (by inputting numbers onto the sliders shown in figure 9), and looking for a result such as that shown in figure 11. The largest number, of say, municipal fishers that the system can support without MPAs is the estimate of what is referred to as *fishery capacity* of the system. The corresponding total catch for this is an estimate of *maximum sustainable yield.*

Simulating the Effects of Commercial Fishers on MPA sizes and Fishery Capacity

The number of commercial fishers input in the appropriate knob does not result in commercial catch being reflected in the graph shown in Figure 11. This is because the commercial fishers will have to be allowed into municipal waters using the slider controlling the **Nearest distance to shore for commercial boats.** Only the catch of commercial fishers in municipal waters are reflected in the output graph since the FISH-BE model version used applies only to municipal waters. It is also assumed that municipal fishers fish only within municipal waters (i.e., within 15 km of municipal coastal baseline).



The slider above allows one to control the area over which commercial and municipal fishers compete in municipal waters. This, coupled with the controls for the number of commercial fishers and their catch, allows one to simulate the effects of commercial fishers on municipal fishers and their catch, as well as MPA sizes.

Evaluating the Economic Effects of Changing Input Values

When one runs the model with the input data, for instance, Determining MPA Size, the socioeconomic effects are shown as numeric displays (figure 12, below).

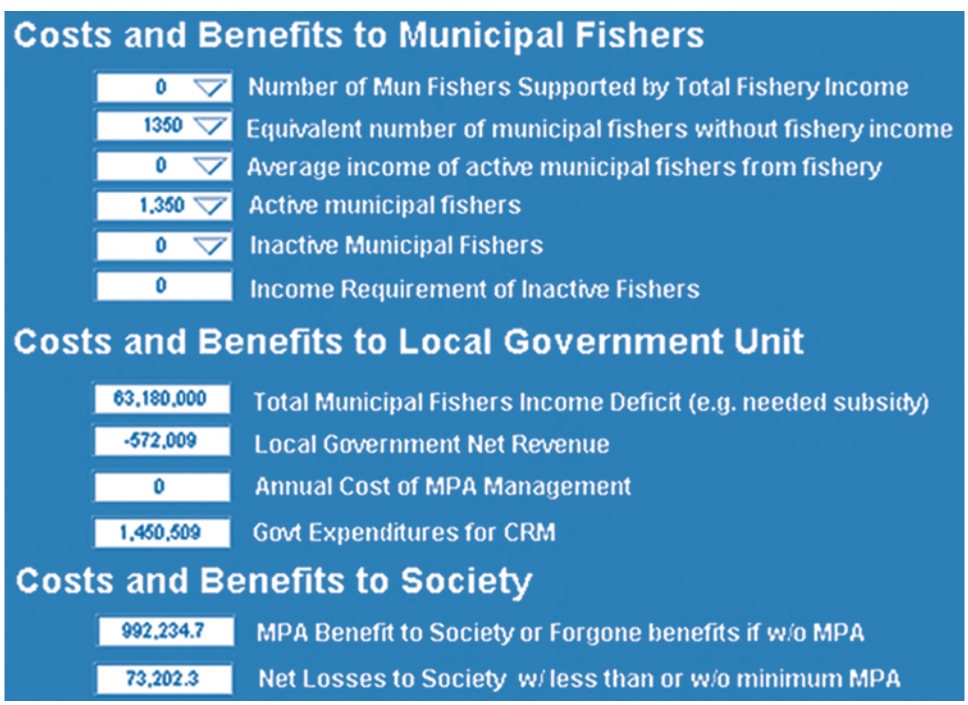


Figure 12. Numeric display of costs and benefits

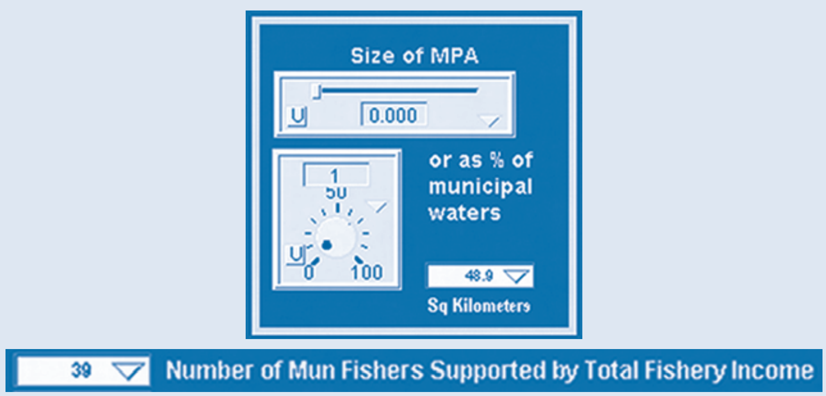
For instance, if one runs the base scenario (without MPA and commercial fishers in municipal waters) the *Number of Mun Fishers Supported by Total Fishery Income* shows "0" in the first numeric display (figure 13 below). The value that is shown ("0" in this scenario) is the last value in the specified simulation period (20 periods).

Figure 13. Numeric display of number of municipal fishers supported by total fishery income

With the collapse of fishery over the period, the eventual income from fishery will become "0." That translates into the number of fishers without fishery income thus, *"Equivalent number of municipal fishers without fishery income"* is the same as the initial number of municipal fishers in this simulation. The values of a control or evaluation variable can be changed and see its effect on the values in the numeric displays.

Example 1: Economic Effect of Introducing an MPA

In Balabac, Palawan the local government unit will introduce an MPA of the size 49 sq km, equivalent to 1% of the area of its municipal waters of 4,890 sq km. Typing in 1 in the "Size of MPA" switch and click RUN the result is shown below:



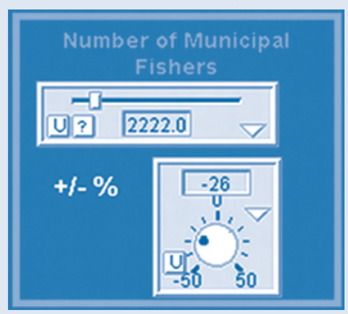
This means that of the total fisher population of 2222, only 39 fishers will be supported by the total income from fishery, because the total income from fishery is very low; that means the total catch is very low. It does not mean, however, that the rest of the fisher population have stopped fishing; simply that, given the average daily expenditure requirement of individual fishers, only 39 could meet this total requirement.

In the model, *Active Municipal Fishers* also translates as the initial municipal fisher population. When one make changes in the radio button to "Increase or Reduce" municipal fishers and RUN the model, the numeric values for *Inactive Municipal Fisher* will change, depending on the direction of change (e.g., a positive change will not change the value, it remains at "0"); the same holds true for the *Income Requirement of Inactive Fishers*. On the other hand, if you change the value in the slider *(Number of Municipal Fishers)* and click RUN, the latter two numeric displays do not change; however, this is true only if the +/-, % radio button value is greater than or equal to "0."

The *Equivalent number of municipal fishers without fishery income* plus *Inactive Municipal Fisher* translates into *Total Municipal Fishers Income Deficit* which has implications on government program, that is, one solution is government subsidy ("Income transfers") or another is alternative livelihood development program for displaced fishers.

Example 2: Economic Effect of Reducing Fishing Effort

Using the Balabac example again, instead of introducing an MPA, one management option is to reduce fishing effort so that the fish catch could be sustained. This is accomplished by using the "Number of Municipal Fishers" switch as shown below. Turn the knob to the left (value becomes negative) and click RUN. Do this until the graph shows sustained catch.



The result indicates that 578 municipal fishers will have to find other sources of income aside from fishing, the rest of the 2222 (1,644 fishers) can continue their fishing activities. However, that is not the whole story, because when you look at the "Number of Mun Fishers Supported by Total Fishery Income" the number is tremendously large, that it even exceeds the initial fisher population by a large margin. The user should understand what drives this result: The "Number of Mun Fishers Supported by Total Fishery Income" has the following formula:

$$\text{Number of Fishers Supported} = \frac{\text{Total Fishery Income}}{\text{Expenditure Required/Fisher Household}}$$

Which means that a number of other variables namely, total fish catch (determined by catch rate and fishing effort), expenditure requirements and price of fish drive the process. The catch rate per day for Balabac fishers is 15 kg/day hence, total catch itself is large. Multiplied by the price of fish, this translates to a large income; however, each fisher's average expenditure requirement, as defined in the model, is only P100. If one puts in a higher value of expenditure requirement, this value can decrease dramatically.

Refining the FISH-BE Models

Modeling makes one look at a system differently and see behaviors one would otherwise miss. Modeling forces the investigator to look at data from a different, more integrated perspective. This makes it easier to identify data gaps, and consider alternative ways of quantifying various parameters relative to others. Modeling thus enriches the data collection process, and better data, in turn, allows for a more refined model in a repetitive loop leading to better understanding. The insights should also then be considered in their application to fisheries management.

Doing Multiple Runs: Sensitivity and Elasticity Analyses

Aside from the minimum MPA sizes, the model can also give insights to the magnitude of the influence of various data inputs on the outputs of the model. With proper planned simulations, one can tell whether MPA size is affected more by municipal or commercial fishers, or whether demersal fish is more important in sustaining catch than pelagic fishes.

To examine the latter, the number of commercial fishers should be kept constant, kept out of municipal waters (i.e., the minimum distance for their boats at 15 km from shore), and done with a series of runs with 100 more municipal fishers than the previous run. Start with 100 municipal fishers until there are 1,000 more than the present number of fishers. Then, keeping the number of municipal fishers at present, allow commercial fishers to 10.1 km from shore and do a series of runs from 100 commercial fishers to 1000 more than their present number. Plot the number of municipal and commercial fishers per run and the corresponding minimum MPA size and compare their impacts. The plot with the greater slope for MPA size is the parameter to which MPA size has greater sensitivity. In other words, these sensitivity analyses show whether 100 municipal fishers have greater impact on MPA size than 100 commercial fishers.

Elasticity is also computed similarly, except that it involves equivalent proportional rather than equivalent incremental changes in input parameters. This allows for comparisons of parameters with different units, such as the impact on minimum MPA sizes of changes (in 10% increments) in the number of days of fishing as opposed to changes (in 10% increments) in area fished.

One of the uses of the Sensitivity and elasticity analyses is to identify which data inputs are critical to given outputs (both in modelling and possibly in real world terms), and thus more effort should be put in collecting and assessing these inputs in the future.

Fishery Capacity Charts

Not for level 1 implementation of the models.

Precautions and Reminders to Users

The results of FISH-BE analyses such as the minimum MPA size and fishery capacity should not be treated as knife-edge estimates but rather approximations that can improve with data quality, but only up to a certain, likely coarse level. If data inputs are not very good or are very rough approximations, FISH-BE outputs will also be the same. Much like the chain's strength is determined by its weakest link, the accuracy of the model outputs are determined by the coarsest data input to which it has greater sensitivity/elasticity.

Even if all the data inputs are very good, FISH-BE results can only be reliable to a certain, likely coarse level. This is because FISH-BE is still based on a simplistic assumption of logistic growth of fish populations. There are more sophisticated models but they also require vastly more data than is available in most Philippine situations.

Thus, when presenting results, avoid misleading the decision makers and stakeholders by showing several decimal points after the results. For example, a "4.0% minimum MPA size" suggests greater precision than a "4% minimum MPA size," when in reality such a result is effectively not different from a 5% minimum MPA size. FISH-BE results are not knife-edge estimates.

The same logistic basis also means FISH-BE is not designed to adequately estimate the time element, for example, the number of years before a stock collapses.

Despite, and perhaps, because of these limitations, FISH-BE is better thought of as a communications tool. FISH-BE helps decision makers and other stakeholders to better understand the intricacies of coastal resource management.