FISHBYTE SECTION

Fishbyte is the Newsletter of the Network of the Tropical Fisheries Scientists

Editorial

We have assembled an array of articles for this issue of *Fishbyte*. Four papers (by Benedito-Cecilio et al., Ruiz-Ramirez et al., Kochzius, and Merella et al.) provide estimates of length-weight relationship parameters. These contributions are data-rich (collectively covering 181 fishes and 15 cephalopods) and are welcome additions to those already incorporated in FishBase. The paper by Jayasankar and Dharmalingam presents results of genetic variation (hence stock intermixing) investigations on *Rastrelliger kanagurta* off India. The contribution of B. Gobert presents a method for evaluating total mortality using length-frequency data when growth parameters are poorly known or unknown.

The paper by Cruz-Trinidad et al. gives the second part (i.e., economic analysis of trawling in Brunei Darussalam) of a four-part series on B:RUN, a low-level geographic information system. The paper by P. Murray suggests an approach or framework for assessment of the finfish fisheries of the Caribbean Community, while the contribution of J. Quensière highlights the main results of a multidisciplinary fisheries research and management program in the Niger River (Mali). We end the issue with an update on FiSAT and the usual news and announcements for NTFS members.

We urge you to read and to keep the 'quality' contributions coming!

G. Silvestre and V. Christensen

A Low-level Geographic Information System for Coastal Zone Management, with Application to Brunei Darussalam

Part II: Economic analysis of trawling in Brunei Darussalam

A. Cruz-Trinidad, G. Silvestre and D. Pauly

Abstract

Economic analysis of the trawl fishery of Brunei Darussalam was conducted using cost and returns analysis and based on an economic survey of trawlers and B:RUN, a low-level geographic information system. Profitability indicators were generated for the trawl fleet under various economic and operational scenarios. The results show that financial profits are earned by trawlers which operate off Muara, particularly those with high vessel capacity, and that these profits could be further enhanced. On the other hand, a similar fleet operating off Tutong would generate profits due mainly to high fish biomass. Trawling operations offshore are deemed financially unfeasible. Incorporating realistic opportunity costs and externalities for existing trawl operations off Muara results in economic losses.

Introduction

In the early 1990s, fisheries contributed a meager 0.12% to total GDP in Brunei Darussalam (Scura and Dalusung 1992). The population, however, is highly dependent on fish and fish products; per capita consumption of fish and fishery products was estimated to be about 40 kg/yr in 1990 compared to the world average of 13 kg/yr. Moreover, an increase in demand for fish is foreseen due to the population increase of 2.5% per annum. Imports account for about two-thirds of fish supply or 4 400 t/yr (Silvestre and Matdanan 1992).

Due to the growing demand-supply gap for fresh fish and government commitment to diversify the oil-based economy, the development of trawling was encouraged from the mid-1980s. Trawling as a commercial activity has a relatively short history in Brunei Darussalam. It was only in 1979-1981 that an extensive trawl survey was conducted to aid planning

in the fishery sector (Beales et al. 1982). Based on this survey, a plan for a phased development of trawl fishery was initiated. With loans obtainable from the Economic Development Board and other incentive schemes operated by the Department of Fisheries (i.e., free set of gear, training and technical support), there were nine trawlers by the year 1989.

In a related development, Brunei Darussalam became involved in the ASEAN-US Coastal Area Management Project (CAMP), under whose auspices an integrated coastal management plan for the country was drawn up. One of CAMP's major activities in Brunei Darussalam was the Fisheries Stock Assessment Project. This project was responsible for the trawl survey of 1989-1990 (Silvestre and Matdanan 1992) which also gathered important economic parameters from trawl operators. These activities were supported by the development at ICLARM Headquarters, Manila of B:RUN, a low-level geographic information system for assessing the coastal resources. Information gathered by the project is stored in spreadsheet formats, read by the interactive software and presented in graphical form, thus making its results immediately accessible to government planners and resource managers (Pauly et al. 1995, 1997).

This contribution presents results of cost and returns analyses generated by the trawl/economic survey and by B:RUN to determine whether a suitable milieu exists for private and/or public sector investment in trawling. The analyses are applied to the area off Muara, which is currently being exploited, and to two other fishing areas, one off Tutong and the other offshore (Fig. 1) in order to study the policy options of using these resources for large-scale import substitution.

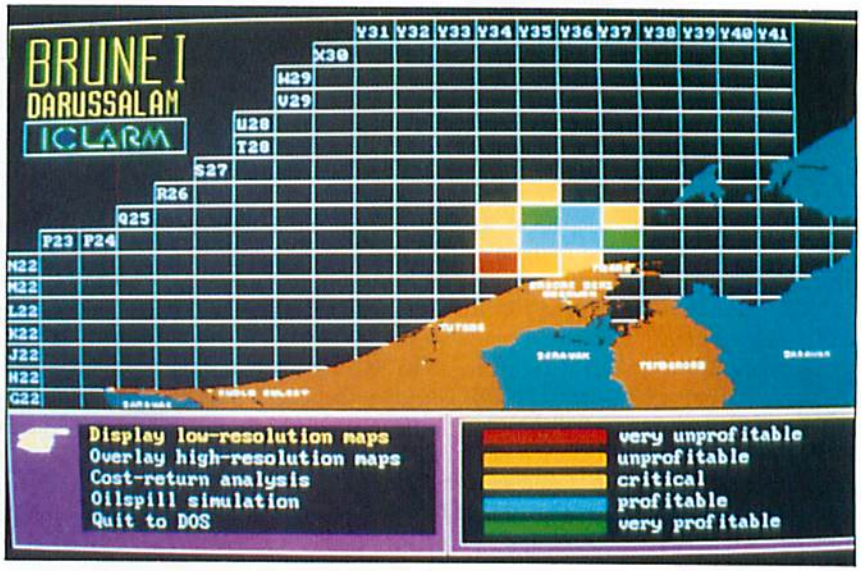

Fig. 1. Grid system used in B:RUN highlighting grid squares representing economic profitability of trawl fishing (1989-1990) off Muara.

Materials and Methods

Within B:RUN, the economic analysis is performed based on a simple surplus-production model (Schaefer 1954; Pauly 1984) providing gross returns (expected catch at a given level of effort times the wholesale price of the fishes caught), from which the cost of fishing is deducted. The inverse linear relationship of catch/effort *vs* fishing effort of trawlers operating off Muara (in colored squares in Fig. 1) was used to define a generic parabolic response of Brunei demersal stocks to fishing. This was then rescaled for all statistical squares off Brunei, using the ratio of the mean trawl survey catch/effort in the area off Muara to that observed in each of the grid squares considered here (Fig. 1).

This resulted in a surplus-production model being defined for each square (Fig. 2). Note that the approach assumes no biomass transfer among squares. This is not a realistic assumption when individual squares are considered but will apply when larger areas, i.e., groups of squares, are compared. In this case, groups of grid squares were aggregated into larger fishing areas (i.e., off Muara, off Tutong and offshore) for evaluation and comparison.

The baseline costs of fishing were defined as given in Table 1. These were modified as required for the various scenarios investigated to force the fishing cost line to start at the origin (zero effort = zero catch = zero costs). The fixed costs of operating a trawler were made proportional to the variable costs generated by a given level of effort. This procedure introduced a downward bias to the cost estimate for low levels of effort. This should not, however, have much impact on the results of the analysis presented here, which tended to favor high levels of effort.

The major factor for trawling off Brunei Darussalam (and elsewhere) is fuel cost. This is a function of fuel price (Table 1), fuel consumption (itself a function of speed, i.e., whether a trawler is

sailing to and from a fishing ground or trawling) and the distance of the home port from the fishing ground. This information is stored inside B:RUN in the form of spreadsheets that include sailing distances from Muara and another (hypothetical) port (Kuala Belait).

Financial indicators (including gross and net profits, return on operating costs and return on investment) were derived for two classes of trawlers, "high" performers and "low" performers, as identified on the basis of their catch rates and frequency of trips. Economic profit is computed with the government as "entrepreneur", implying some adjustments in the valuation of costs and revenues.

Here, we investigated two wage arrangements for trawling off Muara (site of 1989-1990 trawl operations in the country). The analysis of alternative wage structures implies altering the salary component of fixed cost. The scenario wherein wages are paid per trip implies zeroing out the fixed cost component of salaries. Wages per trip were then computed in the spreadsheet program underlying B:RUN based on an hourly wage rate of B$2.98/hour[1] and incentives that include housing, medical allowance and leave credits. The latter are based on hourly rates of deckhands and assuming 50.5 hours worked per week. Housing and medical allowances are 75% and 82% of gross wages, respectively, while leave credits amount to 58% of gross wages (Brunei Department of Labor, unpublished data).

Of the parameters that determine revenue, only prices of fish can be altered. These are entered in the spreadsheet that interacts with B:RUN. The catch rates are based on the trawl survey of 1989-1990 (Silvestre and Matdanan 1992). Effort was expressed as number of trawl hauls per year, i.e., the product of the number of hauls/boat, number of trips/boat/yr and number of boats. Information on cost and returns is generated by B:RUN per fishing area (i.e., off Muara, off Tutong and

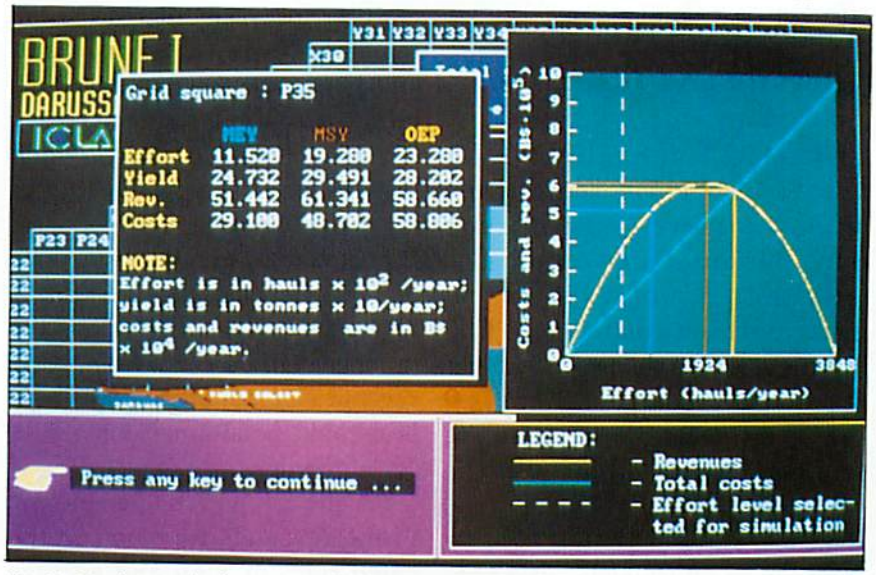

Fig. 2. Surplus-production curve, fishing cost line, and related statistics for a selected grid square (P35). Maximum Sustainable Yield (MSY) is the top of the surplus-production curve, Maximum Economic Yield (MEY) is the level of yield at which the difference between production and cost curve is maximized and Open-access Equilibrium Point (OEP) is the point where production and cost curves meet.

Table 1. Costs of trawling in Brunei Darussalam (1989-1990) as used for the baseline scenario (defaults in B:RUN).

Fixed cost (per month)	
Salaries (B$)	5,240.00
License fee (B$)	20.00
Maintenance cost (B$)	262.00
Interest cost (B$)	1,921.00
Depreciation (B$)	2,946.00
Variable cost (per trip)	
Fuel price (B$/1)	0.42
Lubricant (% of fuel cost)	9.00
Ice (B$)	90.70
Food (B$)	45.35
Miscellaneous (% of total variable cost)	10.00
Other economic parameters	
Inflation rate (%)	3.00
Commission (% of market price)	5.00
Fishing effort	
Hauls/trip	8
Trips/year	60
No. of boats	10

[1]US$1 = Brunei$ 1.80 in 1990.

offshore) and by home port (i.e., Muara or Kuala Belait) by going over all relevant grids that contain information on costs and returns (B:RUN automatically distributes the level of effort per grid square in proportion to the stored catch/effort survey data).

Results and Discussion

The 1989 annual catch of Brunei trawlers based on the economic survey ranged from 8 to 134 tons. Based on the average number of trips, catch per trip was estimated at 0.3 to 1.3 tons/day. An average of 55% of total catch is accounted for by the family Leiognathidae, a group of species whose average wholesale price is relatively low (B$2.08/kg).

Of the seven trawlers surveyed, two can be classified as "high" performers and two as "low" performers, while the remaining three fall in between. There is only a slight difference in operating costs between high and low performers due to the high fixed costs. On the other hand, there is a large difference between the revenues of high and low performers. This results in large losses for the low performers, a negative return on investments and a return on operating cost which implies a larger proportion of costs to net earnings.

We investigated three scenarios: A, B and C. Scenario A represented situations where the number of trips of low performers were maximized to the level of high performers, i.e., from 25 trips/yr to 169 trips/yr. By increasing the number of trips, average fixed cost and, hence, average cost was minimized. Scenario B assumed an average catch of 0.3 t/day, which was the prevailing catch rate of low performers, whereas Scenario C assumed an average catch rate of 0.8 t/day, i.e., the average for all trawlers. By maximizing the number of trips per year, average revenues amounting to B$3.4 million could be attained for a fleet of 10 trawlers.

For the estimation of economic profit, revenues are based on the catch rates of high and average performers and on wholesale prices. However, a very important assumption was made, i.e., that wholesale prices and border prices of fish are equal. Thus, transfer payments such as taxes and interest payment, otherwise entered as costs in financial analysis, are treated as revenues. Expenditures include subsidies on imported capital equipment (assumed to be 10% of capital investment, gear incentives (i.e., first set of trawl gear), and training for crew members. The last, but perhaps the most important component of cost is subsidy to labor. It is assumed that monthly wages are paid by the entrepreneur but housing, medical and leave credits are mainly shouldered by the government. Based on the percentages provided by the Department of Labor, this amounts to B$1 300 per crew member per month or B$776 000 per annum for the entire fleet. Both alternatives show a net economic profit of B$2 million and B$375 000, respectively, for maximum and average fleet capacity utilization. As with financial profits, economic profits increase as capacity utilization of the fleet is maximized. However, incorporating opportunity costs of labor (here assumed to be double the wage rate in the private sector) results in lower profits and to losses in the case of average capacity utilization.

The cost and revenue functions generated by B:RUN confirm the conclusions derived from the economic survey, except that B:RUN assumes that all vessels have the same performance. Fig. 3 shows the cost and revenue curves estimated for Muara. The default level of effort used by B:RUN is 4 800 trawl hauls/yr or 8 hauls/trip, 60 trips/yr and 10 boats (Table 1), which corresponds to the "average" performers among the seven trawlers surveyed. Some profits are earned at the default level, but they can be maximized by increasing fishing effort, e.g., to 12 000 trawl hauls/year (or 156 trips), at which point MEY is attained (for fixed wage levels, C_{FW}). Moreover, the variable wage regime (C_{VW}) permits the attainment of MEY at a lower level of effort, 8 500 trawl hauls/yr, although profits are lower. This implies that

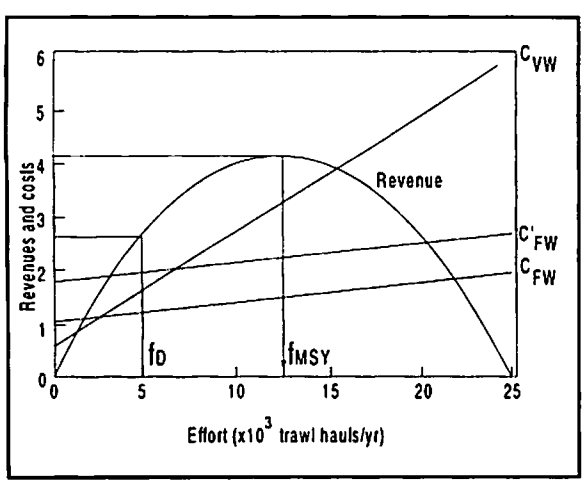

Fig. 3. Revenue and cost of trawling off Muara assuming different wage regimes. C_{FW} corresponds to costs associated with a fixed wage regime and C_{VW} with a variable wage regime. C'_{FW} is a fixed wage regime inclusive of indirect economic cost. The default level of effort (1989/90) is 4 800 trawl hauls per year, while MSY occurs at 12 500 trawl hauls per year.

higher labor incentives would induce a higher rate of resource exploitation.

An illustration of the effects of incorporating direct and indirect economic costs for Muara is represented by the dashed line C_{rw} which imputes the incentives paid to labor amounting to B$776 000 per year as previously estimated. Note further that if opportunity costs of labor, for example, are added, C'_{rw} may move up to a level at which losses are incurred.

Fig. 4 examines the feasibility of deploying the fleet operating in 1989-1990 off Muara to the Tutong area, with either Muara or Kuala Belait as home port. The two cost curves are not significantly different. This suggests that the high demersal biomass off Tutong could be harvested economically, given a suitable fleet deployment generating about 20 000 trawl hauls/year.

The cost and return functions for the offshore area show that it is not financially profitable to deploy the fleet there (Fig. 5), due to the low levels of fish biomass in that area and the distance from both the ports of Muara and Kuala Belait. Thus, MSY is attained at extremely high levels of effort, i.e., 75 000 trawl hauls/yr, which is about seven times greater than that needed for Muara and four times that for Tutong. We have excluded the area off Kuala Belait from our analysis as most of the area is classified as "precautionary" due to the large number of pipelines and other oil industry structures in the area.

Conclusion

Our analysis of trawling off Muara resulted in favorable financial and economic indicators given maximum utilization of the trawler fleet. Financial profits are earned at average fleet utilization, but losses are sustained when direct and indirect economic costs are incorporated. A variable wage regime that provides more incentives to labor was observed to increase resource exploitation. The area off Tutong has a good potential for exploitation, mainly because of high fish biomass. On the other hand, it is evident that there is no economic sense in trawling in the offshore area.

A major limitation of the economic survey is the scarcity of information from which to estimate the opportunity costs of the factors of production and the pricing of externalities induced by trawling. Thus, while economic sense suggests further increase of effort (given that trawl operators are operating profitably), this has apparently not occurred in Brunei. This is mainly due to the strict limits on the number of trawl licenses issued by government but is most probably also due to the opportunity costs of trawling, particularly that of labor and capital. The scarcity of labor in the fishery can be simply attributed to the high opportunity costs of labor[2]. Plans to curtail expatriate labor would imply the need to increase govern-

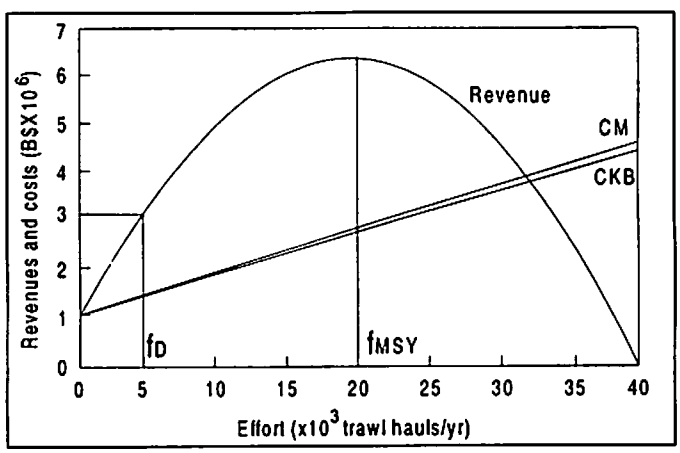

Fig. 4. Revenue and cost of trawling off the Tutong area from the ports of Muara (C_M) and Kuala Belait (C_{KB}). MSY occurs at 20 000 trawl hauls per year.

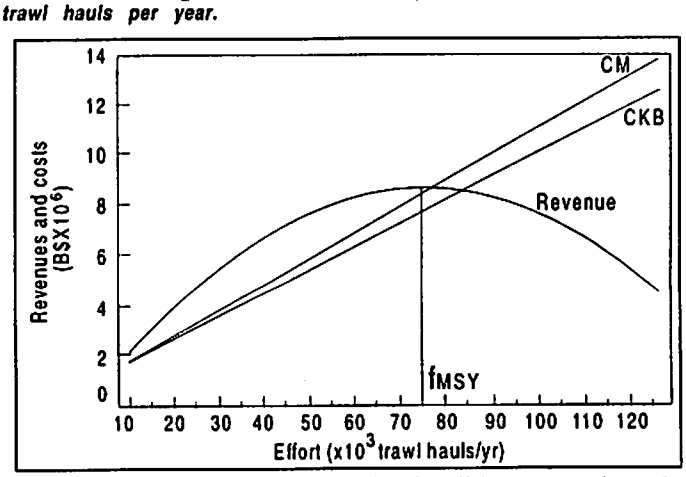

Fig. 5. Revenue and cost of trawling in offshore areas from the ports of Muara (C_M) and Kuala Belait (C_{KB}). MSY occurs at 35 000 trawl hauls per year.

[2] We assume opportunity costs to equal wage rates in the public sector. According to the Brunei Darussalam masterplan on human resource development, the wage differential between the private and public sector has further widened since 1983 in favor of the latter.

ment incentives to the local labor force in order to make fishing as attractive as government employment.

Lastly, there are direct costs and risks attributable to the physical barriers which dot Brunei's coastline, such as oil structures, precautionary areas and non-trawlable bottom substrates.

Overall we conclude that to develop trawl fishery the government would have to inject incentives into the fishery sector. These may take the form of incentives to labor (e.g., training) and private investors (e.g., preferential tax rates, interest and import incentives). Whether such incentives are appropriate in view of negative experiences elsewhere with incentive schemes is a matter for Brunei Darussalam to decide.

Acknowledgments

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