

Catch rates and sustainable yield of Hook and Line Fishery -A Case Study of Kombuthurai village of Thoothukudi district of Tamilnadu

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To estimate the maximum sustainable yield (MSY) and optimum effort (F_{MSY}) values during 2009-2013, the surplus production models (Schaefer and fox) were used. For the Schaefer model, they were 434 tons ($R^2 = 0.99$) and 1252 hours respectively, while from the Fox model the values were 625 tons ($R^2 = 0.99$) and 1000 hours respectively. For the period 2009-2013 the estimated monthly MSY and F_{MSY} values for the Schafer model were 36.95 tons ($R^2 = 0.88$) and 185 hours respectively, while from the Fox model it was 31.8 tons ($R^2 = 0.99$) and 200 hours respectively. The sustainable catch during the study period (2009-2013) on a yearly basis was confirmed from MSY level, and hence, the overall catch can be considered as sustainable.

[**Keywords:** Hook and Line, Maximum sustainable yield, surplus production models]

Introduction

Fisheries are a source of employment, income, nutrition, and recreation in the world. The continuing depletion of the world's marine fisheries resources is a key indicator of the critical decline in ocean health. Moreover, fisheries have been pointed out as one of the five critical global systems according to the first world's ecological health assessment "the Millennium Ecosystem Assessment" carried out by FAO in 2005¹. Use of destructive and unselective fishing gears, such as trawl net damages various important fish habitats, such as coral reefs, seagrass beds etc². Responsible and sustainable fishing methods are the global needs of the time to save the fast depleting resources.

Sustainable fishing is about harvesting fish at an acceptable level of biological and economic productivity, without leading to ecological changes that foreclose options for future generations³. Sustainable fishing techniques focus on an eco-friendly method of fisheries. But will they economically give a helping hand to fishers?. The sustainable environment is equally important to

fisheries economy.

The world's marine fisheries expanded continuously to a production peak of 86.4 million tonnes (mt) in 1996 but have since exhibited a general declining trend. Global marine fish production was 82.6 mt in 2011 and declined to 79.7 mt in 2012 (FAO, 2014)⁴. India's marine fish landings declined 5 percent in 2014 to 3.59 mt against 3.78 mt in 2013⁵. Tamil Nadu produced 6.88 lakh tonnes (lt) of marine fish in 2013 followed by 6.65 lt in the year 2014. The total marine fish production in Thoothukudi during 2010-2011, 2011-2012 and 2012-2013 respectively were 5.31 thousand tonnes (tt), 5.34tt and 5.38tt. Its share of marine fish production in Tamil Nadu remained steady at 12.52% during 2010-2013⁶

The prime focus of this paper is to understand, analyze, document and present the most eco-friendly fishing practices in the selected unique fishing village "Kombuthurai" in Thoothukudi district of Tamil Nadu. The selection of the particular fishing village was done purposively because of the special and unique practice of exclusive hook and line fishing. Hook and line fishing is known to be one of

the most eco-friendly fishing practices in the world. In view of the above, the present paper tried to bring out sustainability of the fishing technique employed and the yield obtained through MSY and F_{MSY} values using surplus production models of Schaefer and Fox. The paper also attempted to bring out the cost and returns of the village per trip using the unique fishing gear.

Materials and Methods

Catch and effort time series data of hook and line fishery from 2009-2013 were taken from fishers associations on month and year wise fish landings in Kombuthurai fishing village. The catch data is in weight in tons (t) and effort taken in the form of

number of fishing days and the time (hrs) spent in the hook and line fishing.

"Surplus production models" is to determine the optimum level of effort that is the effort that produces the maximum yield that can be sustained without affecting the long-term productivity of the stock, the so-called maximum sustainable yield (MSY). Surplus production models can be applied when data are available on the yield and of the effort expended over a certain number of years⁷. The fishing effort must have undergone substantial changes over the period covered. Two surplus production models (SPMs) of Schaefer and Fox model were used. The maximum sustainable yield (MSY) can be estimated from the following input data:

$$f(i) = \text{effort in year } i, \quad i = 1, 2, \dots, n$$

$$Y/f = \text{yield (catch in weight) per unit of effort in year } i.$$

Y/f may be derived from the yield, $Y(i)$, of year i for the entire fishery and the corresponding effort,

$f(i)$, by

$$Y/f = Y(i) / f(i), \quad i = 1, 2, \dots, n$$

The simplest way of expressing yield per unit of effort, Y/f , as a function of the effort, f , is the linear model suggested by Schaefer (1954)⁸:

$$Y(i)/f(i) = a + b * f(i) \quad \text{if } f(i) < -a/b$$

This above equation is called the "Schaefer model."

$$\text{Optimum sustainable yield (F}_{MSY}) = -a/2b$$

$$\text{Maximum sustainable yield (MSY)} = -a^2/4b$$

An alternative model was introduced by Fox (1970)⁹. It gives a curved line when Y/f is plotted directly on effort, f , but a straight line when the logarithms of Y/f are plotted on effort¹⁰

$$\ln \left(\frac{Y(i)}{f(i)} \right) = c + d * f(i)$$

This above equation is called the "Fox model", which can also be written:

$$Y(i)/f(i) = \exp(c + d * f(i))$$

$$\text{Optimum sustainable yield (F}_{MSY}) = -1/d$$

$$\text{Maximum sustainable yield (MSY)} = (-1/d) * \exp(c-1)$$

Results & Discussion

Kombuthurai has been described as a fishing village in Thoothukudi district, Tamil Nadu which has gained immense importance by practicing sustainable fishing practices.

Table 1 gives the catch, effort and catches per unit effort (CPUE) of Kombuthurai during 2009-2013. It can be seen from the table that the CPUE has varied from 0.20 tons to the maximum of 0.25 tons during the period. It is interesting to know that despite the range of effort varied from 1598hrs to 1720hrs. The catch has remained in the range of 347.4 tons to a maximum of 430.8tons. Does this indicate a relationship between their fishing practice of using hooks and lines and relative consistency in the catch?

Table 1: Catch, effort and CPUE of Kombuthurai fishers (2009-2013)

Year	Catch (kg)	Effort (hrs)	CPUE (kg/hr)
2009	362743	1720	210.89
2010	347382	1709	203.27
2011	366146	1643	222.85
2012	430792	1708	252.22
2013	415288	1598	259.88

(Source: Fishers Associations Kombuthurai 2013)

Fig.1 gives the month wise fish landings in Kombuthurai during 2009-2013. The mean fish landings ranged from 28.95 tons in 2010 to 35.90 tons in 2012. Even though the smooth curve of each year does not match on a year to year basis the mean values of fish landings in Kombuthurai indicate relative consistence.

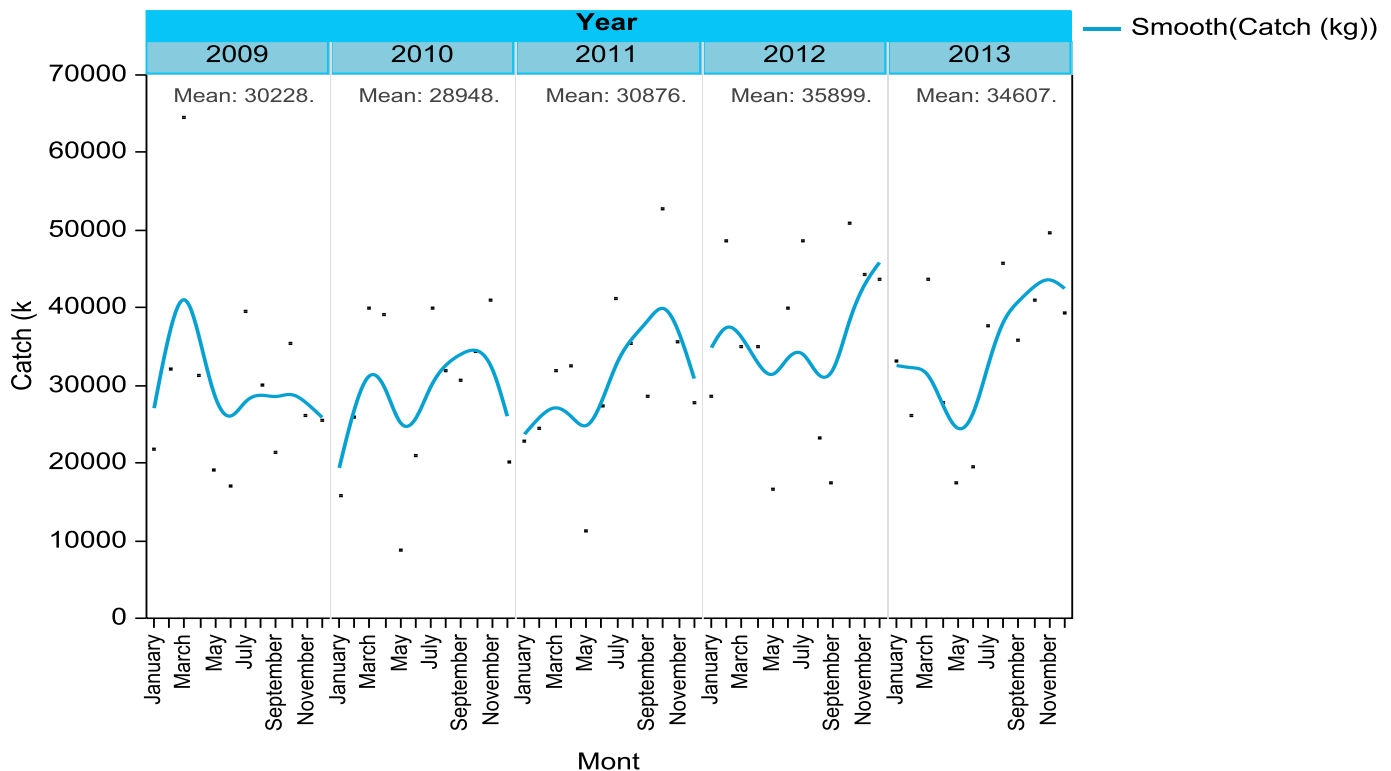


Fig 1: Fish landings in Kombuthurai 2009-2013 Month wise)

The seasonal landings of fish in Kombuthurai are divided into four with a first season February to April; second season May to August; third season September to October and fourth season November to January. This is as per the seasonal calendar followed by the Kombuthurai fishers based on their experience. The first season February to April is identified as best for carangids fishery, the second season for tuna and seerfishes, the third for seer fish, carangids and cuttlefishes and the fourth exclusively for seer fishery.

Thus this division of seasons according to the targeted species of the season and their practice of use of hook and lines indicates a conscious effort at sustainable fisheries in the region. Fig.2 gives the graphical representation of fish landings and effort in Kombuthurai from 2009-2013. It can be seen that when effort decreases fish landings increases. It may be attributed to new hooks, time, fishing grounds and observation of availability of fishes.

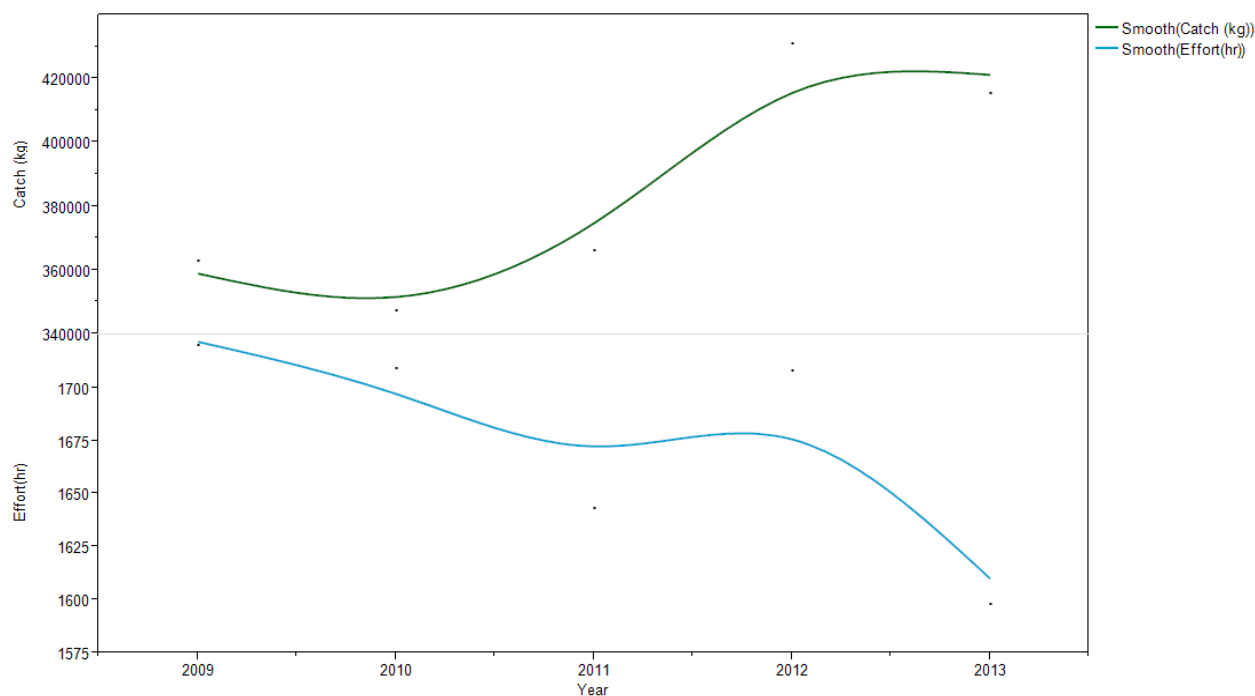


Fig 2: Fish landings in Kombuthurai 2009-2013

Table 2 gives the MSY and F_{MSY} based on both Schaefer and Fox model for year wise. It can be seen that for 2009-2013, estimated MSY and F_{MSY} for the Schaefer model were 434 tons and 1252 hrs respectively. This model explains 99% of the variation in the yield, and for the Fox model, MSY and F_{MSY} were 625 tons and 1000hrs respectively. This model explained 99% of the variation in the yield. Therefore both Schaefer and the Fox model

gave a very good estimate of MSY and F_{MSY} respectively. The estimated MSY and F_{MSY} for the Schaefer model for 2009-2013 across the year monthly basis, were 36.95 tons and 185 hrs respectively. This model explained 88% of the variation in the yield, and for the Fox model, MSY and F_{MSY} were 31.8 tons and 200hrs respectively. This model explained 99% of the variation in the yield.

Table 2: Estimation of MSY and F_{MSY} based on Schaefer's model and Fox's model for catch and effort data of Kombuthurai (2009-2013)

Year	Schaefer			Fox		
	MSY (kg)	F_{MSY} (hr)	R^2 Catch & effort	MSY (kg)	F_{MSY} (hr)	R^2 Catch & effort
2009	33502.75	158.29	0.85	31602.64	166.67	0.98
2010	32719.73	174.62	0.84	28122.28	200	0.98
2011	40022.61	246.44	0.92	40828.8	333.3	0.98
2012	41124.44	181.75	0.87	36618.81	200	0.98
2013	41772.46	201.48	0.94	42001.51	250	0.99
2009- 2013 (Month wise)	36955.69	185.42	0.88	31834.87	200	0.99
2009-2013 (Year wise)	434368.9	1252.26	0.99	625780.7	1000	0.99

Fig.3 gives Schaefer's surplus production model for the years 2009-2013 on a monthly basis and suggests that the MSY of 36.9 tons of catch can be obtained at the optimum fishing effort of 185 hrs.

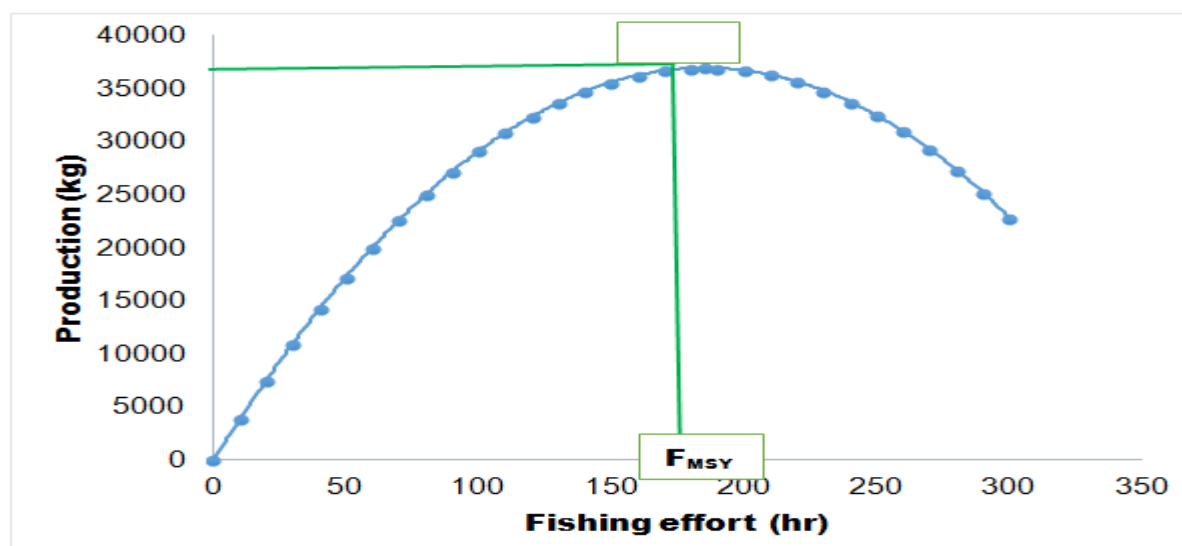


Fig 3: Schaefer's surplus production model (2009-2013- month wise)

Fig.4 gives Fox surplus production model for the years 2009-2013 and suggests that the MSY of 31.8 tons of catch can be obtained at the optimum fishing effort of 200 hrs.

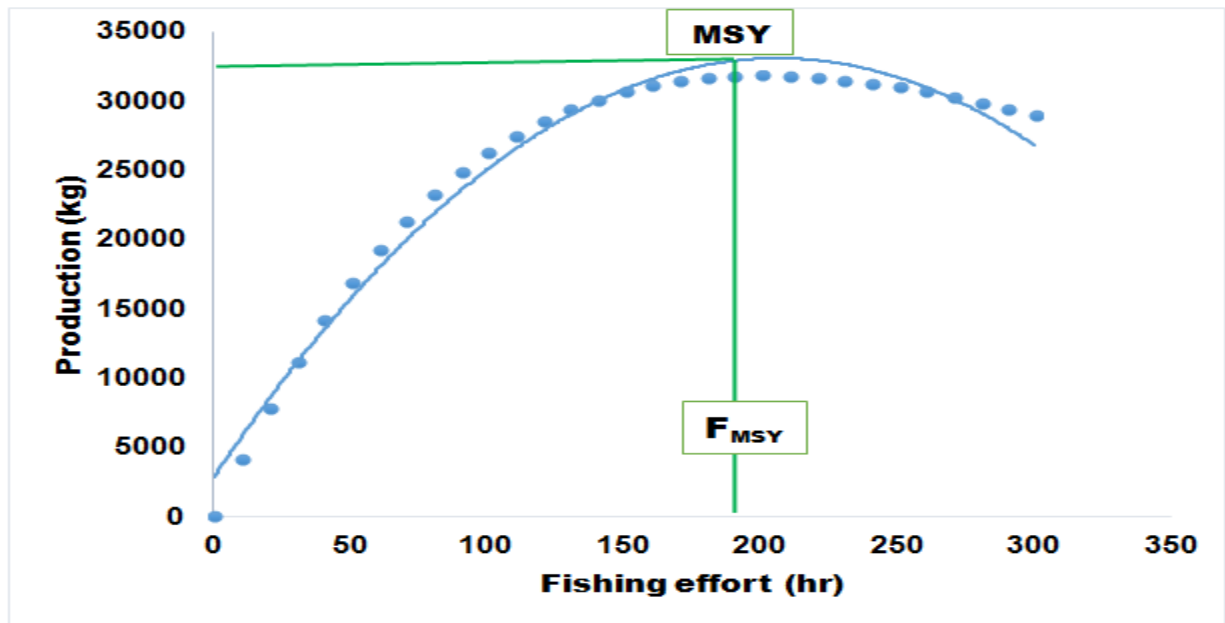


Fig 4: Fox surplus production model (2009-2013- month wise)

Fig.5 gives Schaefer's surplus production model for the years 2009-2013 and suggests that the MSY of 434 tons of catch can be obtained at the optimum fishing effort of 1252 hrs.

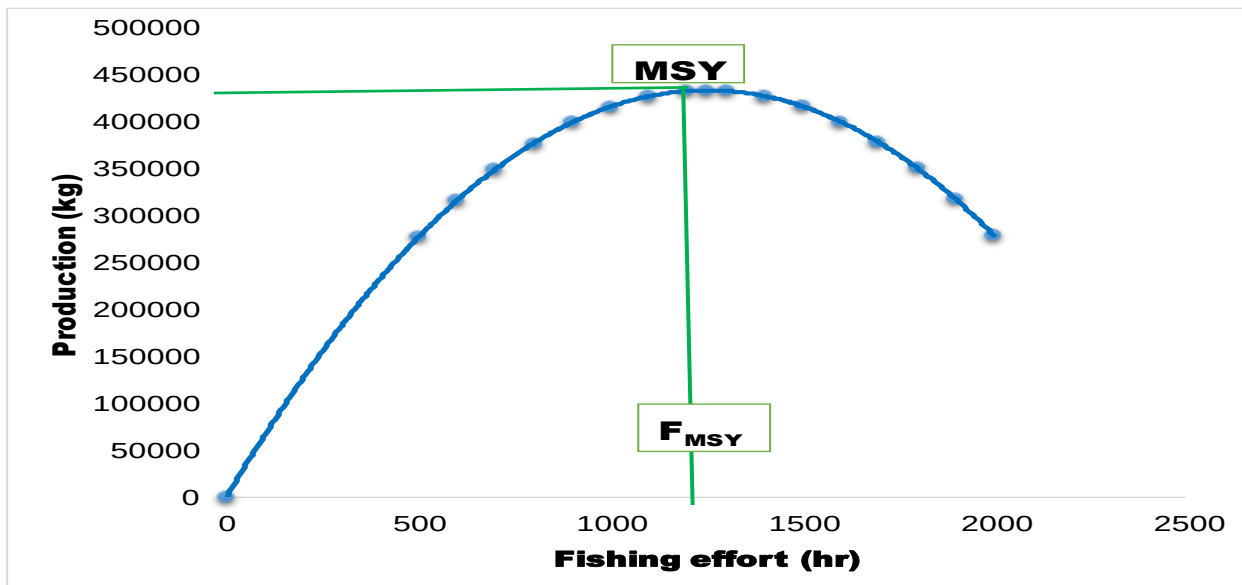


Fig 5: Schaefer's surplus production model (2009-2013)

Fig.6 gives Fox surplus production model for the years 2009-2013 and suggests that the MSY of 625 tons of catch can be obtained at the optimum fishing effort of 1000 hrs.

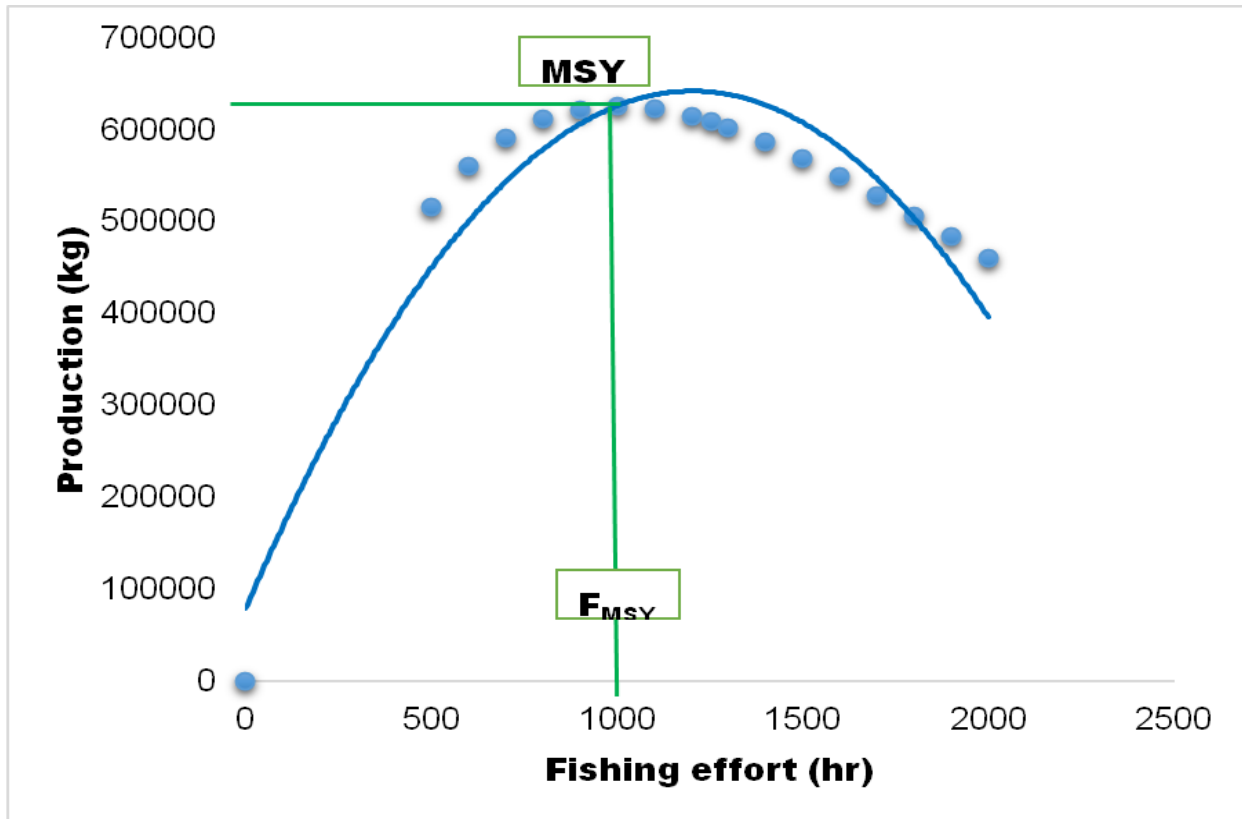


Fig 6: Fox surplus production model (2009-2013)

The catch in the year 2009-2013 on a monthly basis was fluctuating and hence displayed beyond MSY level. But overall catch on year basis of the same period was hence sustainable with MSY level. The fluctuating catch on a monthly basis may be due to the seasonal variance. Therefore the overall catch can be considered as sustainable.

Both Schaefer and the Fox model gave a very good estimate of MSY and F_{MSY} . Nevertheless based on the plotted points and its congruency and the MSY level in Schafer model and fox model. It can be seen that the congruency is almost exact in the Schafer model than the fox model. Therefore the Schaefer model appears to be that one bit a better fit to the data than the fox model under the current dataset forever and the plots obtained from the two models. Therefore MSY has great importance for the conservation of any fish stock. The risk assessment and management

advice from the surplus production models (SPMs) have surprising flexibility and can be used for the traditional assessment of MSY and F_{MSY} ⁷. Moreover, now recently surplus production models have become sophisticated and can generate complex information when realistic models are implemented. Simpler models may be used only to provide a contrasting picture with the sophisticated models⁷.

When surplus production of any stock is greater than the catch it indicates increasing trends in population size, and when catch equals surplus production it tells that catch is sustainable and the population size remains constant. However, if the catch is greater than surplus production, it shows a decline in population. In surplus production models MSY is considered as a biological reference point by which sustainable exploitation goal can be achieved.^{11, 12 & 13}

Table 3 gives the cost of fishing per trip in Kombuthurai. It can be seen that the total operating cost per trip worth ₹ 2765 per trip of one day. Among the operating cost, the major portion of the cost to the extent of 72.33 % (2000/40ltrs) is accounted for expenses on fuel. These boats drove either by outboard motors on Kerosene. Beside kerosene five liters of petrol costing ₹ 365 accounted for 13.25% for the operating cost. Another component of operating cost is the block ice. 1 bar (50 kg) costing ₹ 100 accounts for 3.62% of the operating cost per fishing trips among Kombuthurai fishers. The average gross return per trip is estimated to be ₹ 14, 500 and deducting operating cost per trip is ₹ 11635.

This average value for estimating gross return may differ from season to season and also the targeted species. So in this case, 18 kg of seer fish at an average market price of ₹ 800/kg yielded the estimated gross returns here. Fisher's association plays a major role in Kombuthurai. The FRP boats average Kombuthurai fishers normally use sizes of length 28, 30, 32 feet. The average cost of these boats ₹ 1, 50,000 the maximum boats of FRP boats of estimated to be five years. Boats are normally powered by Yamaha of 9.9 hp. The boats are normally owned by a single fisher who also go on a fishing trip. Four members including the owners undertake each fishing trip.

Table 3: Cost and returns of fishing per trip at Kombuthurai

Cost items	Qty/unit	Value (₹)	Share in cost (%)
Operating cost			
Fuel	40 ltrs	2000	72.33
Petrol	5 ltrs	365	13.2
Block ice	1 bar	100	3.62
miscellaneous		300	10.85
Total operating cost		2765	100.00
Gross return per trip		14400	
Net returns per trip		11635	
Fishers associations			
Pass book	₹3 /100	349	
Associations management	₹3/100	349	
Village maintenance	₹1/100	116	
Pension	₹1/100	116	
saving		1	
Total for fishers associations		931	
Net returns per trip		10704	
Share of the boat		1784	
Share of engine		1784	
Share of the boat owner		1784	
Share of crew members (3)		5352	
Operating ratio		0.19	
Return on investment		4.2	

The gross returns as worked out the tables from ranges from ₹ 14000 to ₹ 20000. After deducting operating cost, the income is divided into six shares. Three shares are going to the owner and other three shares to the crew members.

In addition to facilitating marketing arrangements on the auctioning floor, the fishers also paid for various

services rented by the associations. Payments are made to the associations on the following basis. ₹ 3/100 for maintenance of passbook and associations management, ₹1/100 is paid to the associations for village maintenance and pension respectively. The balance rounded to the nearest multiple of ₹ 100 which is the take-home income of the fishers.

Conclusions

Kombuthurai fishers used hooks and lines for fishing throughout the year. It is economical since it requires less investment on fishing gears and is fuel efficient, helps selective fishing, and causes no disturbance to other traditional and mechanized craft operators. They use fish as baits, and their knowledge is indigenous technical knowledge gained from the experience of their forefathers. Fresh landings fetch better price and revenue both to the owner and the crew. The fishing activity of Kombuthurai fishers showed responsible and sustainable practices which should be popularised among the fishers in other fishing villages of all the maritime states.

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